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MANUAL

OF THE

AMERICAN RAILWAY ENGINEERING ASSOCIATION

The Object of this Association is the Advancement of Knowledge Pertaining to the Scientific and Economic Location, Construction, Operation and Maintenance of Railways. Its Action is not Binding upon its Members.

EDITION OF 1915

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AMERICAN RAILWAY ENGINEERING ASSOCIATION

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g. Miss Margaret Allen. 8 March 1951

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FOREWORD

In the publication of this volume, the Board of Direction of the American Railway Engineering Association feels that while there is still room for improvement, it indicates a decided step forward in the advancement of the Science of Railway Engineering and Maintenance of Way. The Definitions, Specifications and Principles of Practice herein contained are the result of painstaking labors by Standing and Special Committees appointed to consider each subject and of careful consideration by the annual conventions which have been held since the organization of the Association.

It is intended that this volume shall contain results only, but with each subject reference is given to the volume of the Proceedings for the full context of the Committee reports and discussions thereon.

The first edition of the Manual was issued in 1905; the second edition was published in 1907; Supplements containing changes and additions were issued in September, 1906, and September, 1908; a revised edition of the Manual was issued in 1911; Supplements thereto were published in 1912, 1913 and 1914.

The action of the 1915 convention, and a comprehensive revision of the action of previous conventions, is embodied in the present volume.

GENERAL RULES FOR THE PUBLICATION OF THE "MANUAL."

Title.

1. The title of the volume will be "Manual of the American Railway Engineering Association."

Discretionary Powers of Board of Direction.

2. The Board of Direction shall edit the Manual and shall have authority to withhold from publication any matter which it shall consider as not desirable to publish, or as not being in proper shape, or as not having received proper study and consideration.

Adoption of Reports Not Binding.

3. Matters adopted by the Association and subsequently published in the Manual shall be considered in the direction of good practice, but shall not be binding on the members.

Contents.

4. The Manual will only include conclusions relating to definitions, specifications and principles of practice as have been made the subject of a special study by a Standing or Special Committee and embodied in a committee report, published not less than thirty days prior to the annual convention, and submitted by the Committee to the annual convention, and which, after due consideration and discussion, shall have been voted on and formally adopted by the Association. Subjects which, in the opinion of the Board of Direction, should be reviewed by the American Railway Association, may be referred to that Association before being published in the Manual.

5. All conclusions included in the Manual must be in concise and proper shape for publication, as the Manual will consist only of a summary record of the definitions, specifications and principles of practice adopted by the Association, with a brief reference to the published Proceedings of the Association for the context of the Committee report and subsequent discussion and the final action of the Association.

Revision.

6. Any matter published in the Manual may be amended or withdrawn by vote at any subsequent annual convention, provided such changes are proposed in time for publication not less than thirty days prior to the annual convention, and in the following manner: (a) Upon recommendation of the Committee in charge of the subject; (b) upon recommendation of the Board of Direction; (c) upon request of five members, made to the Board of Direction.

7. The Manual will be revised either by publishing a new edition or a supplemental pamphlet as promptly as possible after each annual convention.

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SPECIAL COMMITTEE.

[1]CLASSIFICATION OF RAILWAYS.

Class "A" includes all districts of a railway having more than one main track, or those districts of a railway having a single main track with a traffic that equals or exceeds the following:

Freight car mileage passing over district per year per mile, 150,000; or, Passenger car mileage per year per mile of district, 10,000; with maximum speed of passenger trains of 50 miles per hour.

Class "B" includes all districts of a railway having a single main track with a traffic that is less than the minimum prescribed for Class "A," and that equals or exceeds the following:

Freight car mileage passing over district per year per mile, 50,000; or Passenger car mileage per year per mile of district, 5,000; with maximum speed of passenger trains of 40 miles per hour.

Class "C" includes all districts of a railway not meeting the traffic requirements of Classes "A" or "B."

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[1] Vol. 7, 1906, pp. 331, 340; adopted by letter-ballot, June, 1906; Vol. 8, 1907, p. 15.

COMMITTEE I.

ROADWAY.

[1]DEFINITIONS.

Group A—General.

Classification.—Arranging the material in groups according to its character.

Contract.—A written agreement between two or more parties specifying terms, conditions, etc., under which certain obligations must be performed. (Specifications are a part of the contract.)

Estimate (noun).—(a) A statement of work performed or material furnished, according to which payment is to be rendered.

Estimate (noun).—(b) A statement showing the probable cost of a proposed piece of work.

Estimate (verb).—The act of making an estimate.

Quantities.—The amount of material to be handled, expressed in the usual units.

Slide.—The movement of a part of the earth under the force of gravity.

Specification.—That part of the contract describing the materials for or the details of construction.

Stock-Pass.—A culvert or bridge opening under the track, primarily for the passage of stock.

Unit Price.—The price per unit of the various quantities specified in a contract for which a certain work is to be performed.

Washout.—The carrying off of the permanent way by the impact and erosion of waters.

Group B—Right-of-Way.

Right-of-Way.—The land or water rights necessary for the roadbed and its accessories.

Roadbed.—The finished surface of the roadway upon which the track and ballast rest.

Roadway.—That part of the right-of-way of a railway prepared to receive the track. (During construction the roadway is often referred to as the "grade.")

Station Grounds.—Property to be used for station purposes.

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[1] Adopted, Vol. 7, 1906, pp. 341, 442, 443; Vol. 11, Part 2, 1910, pp. 1063, 1087; Vol. 16, 1915, pp. 566, 1071.

Group C—Technical.

Alinement.—The horizontal location of a railway with reference to curves and tangents.

Center Line.—A line indicating the center of an excavation, embankment or track.

Construction Station.—The center line stake set at the end of each full 100-foot tape or chain length.

Contour.—The line of intersection between a horizontal plane and a given surface.

Cross-Section.—A section through a body perpendicular to its axis.

Center Stakes.—Stakes indicating the center line.

Elevation or Height.—The distance of any given point above or below an established plane or datum.

Finishing Stakes.—Final stakes set for the completion of the work.

Grade (verb).—To prepare the ground for the reception of the ballast and track.

Grade-Line.—The line on the profile representing the tops of embankments and bottoms of cuttings ready to receive the ballast.

Gradient.—The rate of inclination of the grade-line from the horizontal.

Location.—The center line and grade line of a railway established, preparatory to its future construction.

Plan.—A drawing furnished for guidance of work.

Profile.—The intersection of a longitudinal vertical plane with the ground and established gradients; or a drawing representing the same.

Slope.—The inclined face of a cutting or embankment.

Slope Stakes.—Stakes set to indicate the top or bottom of a slope.

Subgrade.—The tops of embankments and bottoms of cuttings ready to receive the ballast.

Top of Slope.—The intersection of a slope with the ground surface in cuts, and the plane of roadbed on embankment.

Toe of Slope.—The intersection of a slope with the ground surface in embankments, and the plane of roadbed in cuts.

Group D—Clearing.

Brush.—Trees less than 4-inch stump-top diameter, shrubs or branches of trees that have been cut off.

Clearing.—Removing natural and artificial perishable obstructions to grading.

Grubbing.—Removing the stumps and roots.

Group E—Drainage.

Bog.—Soft, spongy ground, usually wet and composed of more or less vegetable matter.

Channel.—The depression or cut in which a stream is confined.

Culvert.—An arched, circular or flat covered opening of timber, iron, brick or masonry, carried under the roadbed for the passage of water, or for other purposes.

Drain.—An artificial waterway for conducting water from the roadway.

Drainage.—The interception and removal of water from, upon or under the roadway.

Ditch.—An open artificial waterway for providing drainage.

Intercepting Ditch.—An open artificial waterway for preventing surface water from flowing over the slopes of a cut or against the foot of an embankment.

Subdrain.—A covered drain, below the roadbed or ground surface, receiving the water along its length by absorption or through the joints.

Trench.—A narrow, shallow excavation to receive a structure.

Waterway.—A channel, either natural or artificial, for conducting the flow of water.

Group F—Grading.

Average Haul.—The mean distance material is to be hauled.

Average Total Haul.—The average total distance material is to be hauled.

Benched.—Formed into a series of benches.

Berme.—(a) The space left between the top or toe of slope and excavation made for intercepting ditches or borrow pits. (b) An approximately horizontal space introduced in a slope.

Borrow (verb).—To take material from a borrow pit.

Borrow (noun).—Material removed from a borrow pit.

Borrow Pit.—An excavation made for the purpose of obtaining material.

Embankment (or Fill).—A bank of earth, rock or other material constructed above the natural ground surface.

Excavation (or Cutting).—(a) The cutting down of the natural ground surface; (b) The material taken from cuttings, borrow pits or foundation pits; (c) The space formed by removing material.

Foundation Pit.—An excavation made for laying the foundation of a structure.

Haul.—The distance material is moved in the construction of the roadway.

Free Haul.—The distance within which material is moved without extra compensation.

Overhaul.—The number of cubic yards moved through the overhaul distance multiplied by the overhaul distance in units of 100 feet.

Overhaul Distance.—The distance beyond the free-haul limit that material is hauled in constructing the roadway, for which extra compensation is allowed.

Ramp.—An inclined approach.

Shrinkage.—The contraction of material.

Stepped.—Formed into a series of steps.

Tamped (or Packed).—Packed down by light blows.

Total Haul.—The total distance that material is to be hauled.

Waste.—Material from excavation not used in the formation of the roadway.

Waste or Spoil Banks.—Banks outside the roadway formed by waste.

Group G—Tunnels.

Curb.—A broad, flat ring of wood, iron or masonry, placed under the bottom of a shaft to prevent unequal settlement, or built into the walls at intervals for the same purpose.

Rock.—A solid mass of mineral substance.

Shaft.—A pit or well sunk from the ground surface above into a tunnel for the purpose of furnishing ventilation or for facilitating the work by increasing the number of points from which it may be carried on.

Tunnel.—An excavated passageway under ground or water.

Well (or Sump).—A cistern or well into which water may be conducted by ditches to drain other portions of a piece of work.

[2]GENERAL CONTRACT REQUIREMENTS.

(1) Similarity in the form of specifications.

(2) Measurement of clearing and grubbing should be made in units of one hundred (100) feet square.

(3) A threefold classification of materials: "Solid Rock," "Loose Rock" and "Common Excavation," and in special cases such additional classification of material as may seem necessary, such additional classes to be distinctly defined and specified in the contract.

(4) Profiles should be made complete in regard to distribution of material.

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[2] Adopted, Vol. 4, 1903, pp. 32, 35, 39, 44, 66, 74; Vol. 5, 1904, pp. 688, 719; Vol. 6, 1905, pp. 123, 136. 142, 144, 145, 164-173; Vol. 16, 1915, pp. 567, 1075.

(5) The width between center lines of main tracks on tangent should preferably be not less than 13 feet; on curves this distance may be increased.

(6) Rock excavations should be taken out not less than six (6) inches below subgrade.

(7) No waste should be permitted above subgrade closer than ten (10) feet from the slope stakes.

(8) Information on profiles as to distribution of material should be so arranged that the price for grading for each of the classes may cover the haul, irrespective of distance.

[3]WIDTH OF ROADWAY AT SUBGRADE.

(1) Class A railways, with constant and heavy traffic, should have a minimum permanent width of twenty (20) feet at subgrade.

(2) In the theory upon which the width of embankment at subgrade is based it is considered that the track, in excavations, is placed upon what is virtually a low embankment; and in order to preserve uniformity of conditions immediately under the track throughout the line, the width of subgrade in excavations should be made the same as on embankments, outside of which sufficient room should be allowed for side ditches.

[4]SLOPES OF ROADWAY CROSS-SECTION.

Local conditions and the character of material should invariably be taken into account in determining the permanent slopes of the roadway cross-section.

[5]SPECIFICATIONS FOR THE FORMATION OF THE ROADWAY.

GENERAL.

Alinement.

1. The center of the roadway shall conform in alinement to the center stakes.

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[3] Adopted, Vol. 3, 1902, pp. 34, 37, 43; Vol. 6, 1905, pp. 122, 123.

[4] Adopted, Vol. 3, 1902, pp. 34, 45; Vol. 6, 1905, pp. 122, 123.

[5] Adopted, Vol. 4, 1903, pp. 20-29, 33-35, 78-109; Vol. 5, 1904, pp. 675-684, 688, 719; Vol. 6, 1905, pp. 125-136, 143-164; Vol. 11, Part 2, 1910, pp. 1062, 1063; Vol. 16, 1915, pp. 567, 1075.

Subgrade.

2. The grade-line on the profile denotes subgrade, and this term indicates the tops of embankments or the bottoms of excavations ready to receive the ballast.

Cross-Section.

3. The roadway shall be formed to the section, slopes and dimensions shown upon the standard drawings, or as may be directed from time to time.

Width of Roadway.

4. When finished and properly settled the roadway shall conform to the finishing stakes and shall be of the following dimensions at subgrade, for single track, viz.:

On embankments........................(....) feet wide, and in excavations..............................(....) feet, exclusive of the width necessary for ditches. For each additional track an additional width of.................................(....) feet shall be made.

Slopes.

5. The slopes of embankments and excavations shall be of the following inclinations, as expressed in the ratio of the horizontal distance to the vertical rise:

Embankments, Earth—One and one-half to one;
Rock—From one to one, to one and one-half to one;
Excavations, Earth—One and one-half to one;
Loose Rock—One-half to one;
Solid Rock—One-quarter to one.

These ratios may be varied according to circumstances, and the slopes shall be made as directed in each particular case.

CLEARING.

Extent of Clearing.

6. The right-of-way and station grounds, except any portions thereof that may be reserved, shall be cleared of all trees, brush and perishable materials of whatsoever nature.

Disposal of Brush, etc.

7. All these materials, except as hereinafter mentioned, shall be burned or otherwise removed, as may be directed, and without injury to adjoining property.

Stumps.

8. Where clearing is to be done, stumps shall be cut close to the ground, not higher than the stump-top diameter for trees twelve (12) inches and less in diameter, and not higher than eighteen (18) inches for trees whose stump-top diameter exceeds twelve (12) inches, except between slope stakes of embankments, where stumps shall be cut so that the depth of filling over them shall be not less than two and one-half (2½) feet.

Clearing in Advance.

9. The work of clearing shall be kept at least one thousand (1000) feet in advance of grading.

Cutting and Piling Wood.

10. All trees which may be reserved shall be stripped of their tops and branches, made into ties, or cut to such lengths as may be directed, and neatly piled at such places on the right-of-way as may be designated, for which service payment shall be made by the tie, or by the cord of one hundred and twenty-eight (128) cubic feet.

Isolated Trees, Buildings, etc.

11. Where isolated trees, or where buildings exist, payment shall be made for the removal thereof at a price to be agreed upon before removal.

Measurement.

12. Measurement of clearing and payment for the same shall be by units of one hundred (100) feet square, or fraction thereof, actually cleared.

GRUBBING.

Extent.

13. Stumps shall be grubbed entirely from all places where excavations occur, including ground from which material is to be borrowed as well as from ditches, new channels for waterways and other places where required.

Grubbing shall also be required between the slope stakes of all embankments of less than two and one-half (2½) feet in height.

Grubbing in Advance.

14. The work of grubbing shall be kept at least three hundred (300) feet in advance of grading.

Measurement.

15. Measurement of grubbing shall be estimated upon all excavation actually done, and the space to be covered by all embankments of less than

two and one-half (2½) feet in height. Payment for the same shall be by units of one hundred (100) feet square, or fraction thereof, actually grubbed.

GRADING.

16. The term "Grading" in these specifications includes all excavations and embankments for the formation of the roadbed, ditching, diversions of roads and streams, foundation pits, and all similar works pertaining to the construction of the railway, its sidetracks and station grounds.

Work Included—Classification.

17. All material excavated shall be classified as "Solid Rock," "Loose Rock," "Common Excavation," and such additional classifications of material as may be established before the award of the contract.

Solid Rock.

18. "Solid Rock" shall comprise rock in solid beds or masses in its original position which may be best removed by blasting; and boulders or detached rock measuring one cubic yard or over.

Loose Rock.

19. "Loose Rock" shall comprise all detached masses of rock or stone of more than one cubic foot and less than one cubic yard, and all other rock which can be properly removed by pick and bar and without blasting; although steam shovel or blasting may be resorted to on favorable occasions in order to facilitate the work.

Common Excavation.

20. "Common Excavation" shall comprise all materials that do not come under the classification of "Solid Rock," "Loose Rock," or such other classifications as may be established before the award of the contract.

Finishing Slopes.

21. Slopes of all excavations shall be cut true and straight, and all loose stones in the slopes shall be removed.

Excavation Below Subgrade.

22. Rock excavation shall be taken out....................(....) inches below subgrade and refilled to subgrade with approved material.

Excess Excavation and Slips.

23. Excavation in excess of the authorized cross-section, as well as slides extending beyond the slope lines, shall not be paid for unless due to causes beyond the control of the contractor or his agents. In all cases the surplus material shall be removed by the contractor without delay

and the slopes reformed. The classification of the material shall be in accordance with its condition at the time of removal, regardless of prior conditions. The measurement of the material shall be the original space occupied regardless of the classification.

Disposal of Excess Excavation.

24. Where the quantity of excavation exceeds that required to make the embankments to standard cross-section, the surplus shall be used to widen the embankments uniformly, along one or both sides, as may be directed, and no material shall be deposited in waste banks unless such waste be indicated either on the profiles or by written order.

Waste Banks.

25. Where wasting is ordered the material shall, if possible, be deposited below grade-line, and under no circumstances shall the waste bank have its nearest edge within..........(....) feet of the slope stakes of the cutting.

Borrow Pits.

26. Where the quantity of excavation from the cuttings of standard cross-section is insufficient to form the embankments, the deficiency shall be made up by widening the cuttings on one or both sides of the center line, as may be directed. No material shall be taken from borrow pits, unless such borrow be indicated either on the profiles or by written order.

Approximate Quantities Shown.

27. The classification and quantities shown on the profile exhibited for distribution of material are approximate only, and shall in no way govern the final estimate. The Company reserves the right to increase or diminish the quantities given without affecting the contract unit prices for the various parts of the work.

Reserving Gravel.

28. Gravel, stone or any other material suitable for special use of the Company, which is found within the excavations, shall, when required, be reserved and deposited in convenient places on the right-of-way, as directed. Other suitable material in the vicinity shall be substituted, as required, to complete the embankments.

Berme in Rock Cuttings.

29. A berme of...................(....) feet shall be left between the top of slope of rock cuttings and toe of slope of the overlying earth.

Intercepting Ditches.

30. Intercepting ditches, when ordered, shall be made at the top of the slopes of all cuttings where the ground falls toward the top of the slopes.

These ditches must diverge sufficiently to prevent erosion of the adjoining embankment. The cross-sections and locations of such ditches shall be designated. If required, they shall be excavated in advance of opening the cutting.

Ditches in Cuttings.

31. Ditches shall be formed at the bottoms of the slopes in cuttings, according to cross-sections shown upon the plans, or such modifications thereof as may be directed. They shall be neatly made, clear of obstruction, and at the lower ends must diverge sufficiently to prevent erosion of the adjoining embankments.

Subdrains.

32. Subdrains of tile shall be constructed of the size and location as directed. Trenches for these drains shall be taken out at least...... ....(....) inches below frost line; the tiles shall be laid on a bed which shall be true, with half-round sections, with a filling of at least..........................(....) inches of cinders or other suitable material on either side and above the tile, and then covered with ordinary soil to the top of the trench.

Measurement and payment for such drains shall be by the linear foot, according to the diameter of tile, including excavation and refilling; the contractor to furnish all material.

Unsuitable Material.

33. Excavations incident to the construction of the roadbed, ditches, channels and roadways shall be used in forming the embankments. Frozen or other unsuitable material shall not be permitted to enter into their composition.

Formation in Layers.

34. When directed, embankments shall be built in horizontal layers of........................(....) feet in thickness. These layers must be of the full width of the embankment and built to the true slope, and not widened with loose material from the top. The most suitable material shall be reserved for finishing the surface; large stones shall not be permitted within a depth of at least............(....) feet below subgrade.

Shrinkage.

35. Embankments shall be carried to such height above subgrade and to such increased width as may be deemed a necessary provision for shrinkage, compression and washing. As the embankments become consolidated, their sides shall be carefully trimmed to the proper slopes, and

they must be maintained to their proper height, dimensions and shape until the work is finally accepted.

Embankments on Slopes.

36. Where an embankment is to be placed on sloping ground, the surface shall be deeply plowed or stepped. Whenever directed, boggy or unsuitable material shall be excavated so that the embankment shall be on a firm foundation.

Embankments Across Swamps.

37. In crossing bogs or swamps of unsound bottom for light fills, a special substructure of logs and brushwood may be required. The logs forming this foundation to be not less than six (6) inches in diameter at the small ends. If necessary, there shall be two or more layers crossing each other at right angles. The logs of each layer shall be placed close together, with broken joints, and covered closely with brush. The bottom layer shall be placed transversely to the roadway, and shall project at least five (5) feet beyond the slope stakes of the embankment.

Measurements and payment for this substructure shall be by units of one hundred (100) feet square, or decimal thereof, of area covered by each layer.

Filling Trestles.

38. In forming embankments from trestles, the material shall be thoroughly compacted between the trestle bents and around and under all parts of the structure. In case of train filling by means of a temporary trestle, the material shall be uniformly spread in the fill.

Embankments at Trestles.

39. Embankments abutting the ends of trestle bridges shall be brought forward upon the structure a distance of at least............(....) feet, with increased width of....................(....) feet in order to form a full roadbed.

Finishing Subgrade.

40. The subgrade shall be compact and finished to a true plane, thus leaving no depression that will hold water.

Embankments Over Masonry, etc.

41. Material for embankments over or about masonry or other structures shall be deposited in thin layers, and each layer carefully tamped. Special care must be exercised that no excessive strain be placed upon these structures. Only the best material shall be permitted for the purpose

of such filling. The contract price for excavation shall cover the cost of obtaining, distributing and packing the material behind, over and around all such structures.

BORROW PITS.

Land Provided.

42. Land for borrow pits or waste banks shall be provided by the Railway Company.

Drainage.

43. Borrow pits shall be connected with ditches and drained to the nearest water course, when required. Unless directed, material shall not be borrowed to a depth that will prevent proper drainage.

Slopes and Bermes.

44. Side slopes of borrow pits on the right-of-way shall be the same as used in the cross-section of the adjoining roadway. A berme of not less than....................(....) feet in width shall be left between slope stakes of the embankment and the edge of the borrow pit. A berme of not less than....................(....) feet shall be left between the outside slope of the borrow pit and the right-of-way line. Bermes shall consist of the original unbroken ground.

Cross-Sectioning of Pits.

45. Borrow pits shall not be excavated before they have been staked out. Borrowing must be done in regular shape in order to admit of ready and accurate measurement. Borrowing or wasting of material will not be permitted on land set apart for station grounds or for other special purposes, except by written directions.

PRICE AND MEASUREMENT OF GRADING.

Basis.

46. Grading shall be estimated and paid for by the cubic yard at the prices specified for the respective materials. Measurements shall be made in excavation only, except as hereinafter mentioned.

Work Included in Price.

47. The contract price per cubic yard shall include the excavation of the material by any method whatsoever; the loading, transportation and deposit of the same in the manner prescribed by these specifications and in the places designated; the plowing or benching of the slopes, and all other expenses incident to the work of grading.

Haul.

48. Unless otherwise specified, it is distinctly understood that the contract price per cubic yard covers any haul found necessary. No allowance will be made for any so-termed overhaul.

ALTERNATE OPTIONAL OVERHAUL CLAUSE.

(The following alternate optional overhaul clause is recommended to be substituted for clause No. 48 of the Specifications for the Formation of the Roadway in case it is desired to allow overhaul.)

Haul.

48-a. No payment shall be made for hauling material when the length of haul does not exceed the limit of free-haul, which shall be........feet.

The limits of free-haul shall be determined by fixing on the profile two points—one on each side of the neutral grade point—one in excavation and the other in embankment, such that the distance between them shall equal the specified free-haul limit and such that the included quantities of excavation and embankment shall balance. All haul on material beyond the free-haul limit shall be estimated and paid for on the basis of the following method of computation, viz.:

All material within this limit of free-haul shall be eliminated from further consideration.

The distance between the center of gravity of the remaining mass of excavation and center of gravity of the resulting embankment, less the limit of free-haul as above described, shall be the overhaul distance.

Overhaul shall be computed in units of one cubic yard moved 100 feet and compensation to be rendered therefor shall be computed on such units.

In case material is obtained from borrow pits along the embankment and runways constructed, the haul shall be determined by the distance the team necessarily travels. The overhaul shall be determined by multiplying the number of cubic yards so hauled by one-half the round distance made by the team, less the free-haul distance. The runways shall be established by the Engineer.

Embankment Measurement.

49. If it be impracticable to measure borrowed material in excavation, it may be measured in embankment, using the cross-section notes of the embankment, and making a just and reasonable allowance for change in bulk, so that the quantities shall equal the excavation quantities as nearly as possible.

Borrow Classification.

50. No classification or allowance shall be made for loose or solid rock in borrow pits unless specific written instructions are given to the contrary, it being the intent and meaning of these specifications that all borrowed material shall be classified and paid for as common excavation.

TUNNEL EXCAVATION.

Line, Grade and Cross-Section.

51. Tunnels shall be excavated to the alinement, gradients and sections shown upon the plans, or to such modifications thereof as may be directed.

Bottom of Rock Tunnels.

52. The material from rock tunnels shall be taken out.............. (....) inches below subgrade and refilled to subgrade with approved material.

Blasting.

53. Blasting shall be done with all possible care, so as not to damage the roof and sides. All insecure pieces of rock beyond the standard cross-section shall be removed by the contractor.

Excess Excavation.

54. Excavation in excess of the authorized cross-section shall not be paid for.

Price to Include.

55. The price paid for tunnel excavation shall embrace the cost of removal of all materials between the outer faces of the portals. It shall include the loosening, loading, transportation and placing of the materials in embankment or waste banks, as directed. It shall also include whatever materials and labor are required for temporary props, supports and scaffolding for the safe prosecution of the work, as well as all expense of keeping the tunnel ventilated and free from water, oil or gas.

Niches or Recesses.

56. Niches or recesses for the protection and convenience of the railway employés shall be provided at designated intervals.

Shafts.

57. The location, number and dimensions of all shafts shall be determined. The excavation price for them shall cover all materials contained within the specified cross-section between the surface of the ground and

the connection of the shafts with the tunnel. This price shall also cover all material and labor for curbing and support of the sides of the shafts as may be required, the cost of keeping the shafts ventilated and free from water, oil or gas, as well as the cost of all pumping and hoisting machinery.

Wells or Sumps.

58. Wells or sumps within the tunnel necessary for its permanent drainage shall be made as directed and paid for at the same rate per cubic yard as for tunnel excavation.

Right-of-Way for Roads.

59. The contractor shall, without loss or liability to the Company, construct all roads necessary for his use in the execution of this contract.

Haul.

60. The contract price per cubic yard for tunnel and shaft excavation respectively, cover any haul found necessary in placing the material where designated, within limits agreed upon. There shall be no allowance for any so-termed overhaul.

CLAUSES SPECIALLY APPLICABLE TO REVISION OF EXISTING LINE OR WIDENING FOR ADDITIONAL TRACK.

Safety of and Delay to Train Service.

61. The contractor shall arrange his work so that there will be no interference or delay in any manner with the train service of the Company. He shall be responsible for any damage to the Company's property caused by his acts or those of his employés. Whenever the work is liable to affect the movement or safety of trains, the method of doing such work shall first be submitted for approval, without which it shall not be commenced or prosecuted. If continuous detention occurs to the train service, the Company reserves the right to complete the work at the expense of the contractor after giving him written notice.

Precautions for Safety of Trains and Tracks.

62. Heavy blasting shall not be permitted close to the main tracks, nor shall the contractor be permitted to transport material along or between the Company's tracks, except when properly authorized. Whenever the work as authorized affects the safety of the trains or tracks, the Company shall take such precautions as it may deem advisable to insure safety. The cost thereof shall be charged to the contractor and deducted from his estimate.

When and How Company's Tracks May be Moved.

63. The contractor shall not move the Company's tracks or in any way interfere with them under any circumstances. Whenever it becomes necessary that the main line or sidetracks be moved, it shall be done by the Company, and the actual cost thereof charged to the contractor and deducted from his estimate.

Location of Additional Tracks.

64. The location of the additional track shall be on the .... side of existing line. But whenever it is expedient to change any portion to the opposite side, the altered alinement shall be shown upon the maps or diagrams furnished by the Company, and the contractor shall conform to the same without extra charge.

Plowing Slopes.

65. Wherever the existing embankment of..................(....) feet in height or over is raised or widened, the slope of the existing embankment shall be deeply plowed in order to bind the new material thoroughly to it.

Crossings.

66. Wherever it is necessary for material of any description to be transported across the existing track or tracks, the location of the crossings must be approved. The material and labor of placing and maintaining the same shall be furnished by the Company. The actual cost shall be charged to the contractor and deducted from his estimate.

Watchmen, Operators and Flagmen.

67. Day and night watchmen shall be furnished by the Company at the places it may consider necessary for the safety of the Company's trains and works. The cost shall be charged to the contractor and deducted from his estimate. It is distinctly understood, however, that the providing of such watchmen shall not relieve the contractor from the liability and payment for damages caused by his operations.

Safety Signals.

68. The cost of installment, maintenance and operation of all signals necessary to ensure the safety of trains, consequent upon the contractor's work, shall be borne by the contractor, and all instructions regarding their observance shall be strictly obeyed by him.

GENERAL CONDITIONS.

Temporary Fences.

69. Previous to or during the work of grading, the contractor, if directed, shall erect and maintain temporary fences in order to prevent trespass upon the railway or damage to adjoining property.

Crossings, Damage to Property.

70. The contractor shall, at his own expense, make and keep in good condition commodious passing places for public and private roads traversed by the line of railway; and he shall be held responsible for damages of whatsoever nature to persons or neighboring property caused by workmen in his employ leaving gates or fences open, blasting rock, building fires or in other ways. If necessary, the payment of the estimate may be withheld until such damages are satisfactorily adjusted. The intention of the contract is that the Company shall not be held responsible for any claims or losses incurred during the construction of the line due to the operation or negligence of the contractor or his employés.

Changes of Alinement or Gradients.

71. The alinement, gradients and cross-sections of the roadbed, as well as ditches and other incidental work, may be altered in whole or in part, as deemed necessary, either before or after the commencement of the work. But any such change or alteration shall not affect the unit prices specified in the contract; nor shall any such changes or alterations constitute claims for damages, nor shall any claim be made or allowed on account of such changes or alterations.

Snow and Ice.

72. Before beginning and during the progress of the work, the contractor shall remove all snow and ice from between the slope stakes at his own expense.

Bench Marks and Stakes.

73. The contractor shall carefully preserve all bench marks and stakes. In case of neglect to do so, he will be charged with the resulting expense.

Roads.

74. Wherever required, the contractor shall open up a safe road for passage on horseback and foot along the whole or any portion of the work under contract.

Temporary Roads, Trestles, etc.

75. No allowance or compensation whatsoever shall be due or paid to the contractor for any temporary roads, bridges or trestles that he may make to facilitate the work.

Final Clearing Up.

76. Before the work is finally accepted the contractor shall at his own expense clear away from the Company's property, as well as from public and private roads and the channels of streams and ditches, all rubbish and surplus blasted or excavated material.

Extra Work.

77. The cost of any extra work shall not be considered or allowed, unless such extra work shall have been done by direction, in writing. Such written directions shall in every case contain the rates and methods of payment for said extra work.

Contractor's Risk.

78. The contractor shall take all risks from casualties of every nature, and shall not be entitled to any compensation for detention from such causes. The contractor assumes risk of personal liability and damage to stock, tools and machinery used on the work while on the property of the Railway Company, and the contractor agrees to make no claim therefor which may be caused by the operation of the railway.

Company Defined.

79. Wherever the word "Company" is used in these specifications it designates the..Company.

Contractor Defined.

80. The word "Contractor" is used herein to designate the person or persons undertaking the work referred to in these specifications and drawings.

Work in Charge of.

81. In the foregoing specifications it is understood and agreed that the Chief Engineer of the....................................Company is in charge of the work, and that he may appoint such assistants as he may select. Wherever the specifications refer to the judgment, direction, decision, approval, etc., of any employé of the................Company, they designate and mean the Chief Engineer or one of his assistants. The decision of the Chief Engineer shall be final as to the intent and meaning of these specifications.

Specifications Part of Contract.

82. The specifications and general conditions referred to are distinctly understood as being embodied with the contract, the whole forming the entire agreement between the Company and the Contractor.

[6]STEAM SHOVELS.

GENERAL REQUIREMENTS.

Three cardinal points should be given careful attention in the selection of a steam shovel for roadway construction. These are in their order:

(1) Care in the selection, inspection and acceptance of all material that enters into every part of the machine.

(2) Design for strength.

(3) Design for production.

GENERAL SPECIFICATIONS FOR A MODERN STEAM SHOVEL OF 70 TONS WEIGHT FOR ROADWAY CONSTRUCTION.

Weight of shovel: Seventy (70) tons.

Capacity of dipper: Two and one-half (2½) yards.

Steam pressure: One hundred and twenty (120) pounds.

Clear height above rail of shovel track at which dipper should unload: Sixteen (16) feet.

Depth below rail of shovel track at which dipper should dig: Four (4) feet.

Number of movements of dipper per minute from time of entering bank to entering bank: Three (3).

Character of hoist: Cable.

Character of swing: Cable.

Character of housing: Permanent for all employés.

Capacity of tank: Two thousand (2000) gallons.

Capacity of coal bunker: Four (4) tons.

Spread of jack arm: Eighteen (18) feet. A special short arm should be provided.

Form of steam shovel track: "T" rails on ties.

Length of rails for ordinary work: Six (6) feet.

Form of rail joint: Strap.

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[6] Adopted, Vol. 8, 1907, pp. 298-302, 343-346; Vol. 16, 1915, pp. 573, 1081.

REPAIR PARTS NECESSARY TO CARRY.

1 Hoisting Cable,
1 Thrusting Cable,
1 Swinging Engine Cable,
1 Set Dipper Teeth,
1 Dipper Latch,
Duplicate of each Sheave on Machine.
12 Cold Shuts,
6 Cable Clamps,
1 U Bolt,
Lot assorted Bolts and Nuts,
Lot assorted Pipes and Fittings,
Lot assorted Waterglasses.

REPAIR TOOLS NECESSARY TO CARRY.

1 Blacksmith Forge with Anvil and complete tools,
1 Small Bench Vise,
3 Pipe Wrenches, assorted sizes,
3 Monkey Wrenches, assorted sizes,
6 Stilson Wrenches, assorted sizes,
1 Ratchet, with assorted Twist Drills,
6 Round Files, assorted sizes,
1 Hacksaw, with twelve blades,
1 Set Pipe Taps and Dies,
1 Set Bolt Taps and Dies,
6 Cold Chisels, assorted sizes,
2 Machinists' Hammers,
2 Sledges,
2 Switch Chains,
2 Re-railing Frogs,
2 Ball-Bearing Jacks,
2 Spike Mauls,
2 Clawbars,
1 Siphon, complete,
1 Axe,
1 Hand Saw,
1 Set Triple Blocks with rope,
2 Lining Bars,
1 Pinch Bar,
6 Shovels,
6 Picks,
1 Coal Scoop,
1 Flue Cleaner,
1 Fire Hoe,
1 Clinker Hook,
1 Slash Bar,
2 Hand Lanterns,
2 Torches,
1 Track Gage,
4 Rail Clamps.
Assortment of Packing,
Assorted Oil, in cans.

[7]METHODS OF HANDLING STEAM SHOVEL WORK.

DUMP CARS.

Gage of track for dump cars: Standard (4 feet 8½ inches).

Style and capacity of cars: 12 to 20-yard air dump cars are preferable. Flat cars or cars connected by aprons may be used.

FLAT CARS.

The following points should be observed in the selection of flat cars for steam shovel work:

(1) Car should be strong enough for the purpose.

(2) Brake-wheels should be in good condition, and in case material is to be plowed off, they should be placed at side of car.

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[7] Adopted, Vol. 8, 1907, pp. 302-306, 346-349, 350.

(3) Stake pockets should be in good condition and not spaced too far apart. Four feet apart in center of car and closer at ends is good practice.

(4) Stakes should be strong enough to prevent accident or derailment of plow.

PLOWS AND SPREADERS.

Where dirt is dumped from trestle in fill for haul less than two miles, light cars and light trestles are recommended.

For handling unloading plows, a cable with an auxiliary engine and drum is recommended. The machine should be able to develop sixty (60) ton pull, and weigh about 28 tons; steam cylinders, 12 inches by 12 inches; diameter of drum, 4½ feet, permitting four wraps of 1½-inch cable to be made.

When raising track, the center plow is recommended when raise is light; side plows are recommended for making heavy fills.

A strong plow with trailer is recommended; it should be not less than four and one-half (4½) feet high and thirty-six (36) feet in length over all.

Weight of plow: Seven (7) tons.

Size and length of cable: One and one-half (1½) inches in diameter and 1200 feet in length.

Form of spreader: Two-arm.

Method of handling spreader: Air.

Spread of wings: Twenty (20) feet.

Limiting angle of wings: Forty-five (45) degrees.

Height above rail at which spreader should deposit material: Two (2) feet.

Depth below rail at which spreader should work: Two (2) feet.

VERTICAL LIMITS.

In making embankments with trains on new location, the following vertical limits are recommended for the respective conditions:

(1) For raising track with material dumped: Four (4) feet.

(2) For a central core put up by teams and widened with shovel material: Not to exceed four (4) feet.

(3) For temporary filling trestle: Under ordinary conditions, temporary trestle for fills over four (4) feet in height.

In making embankments with trains in present location of track under traffic, under ordinary conditions, where sand, gravel or cinders can be used, it is economical to jack main track vertically in place if raise does not exceed four (4) feet.

Where traffic is heavy and track is to be raised more than four (4) feet, it is economical to carry traffic over a temporary track built on one side while the main track is jacked vertically in place.

Where raise of track is to exceed six (6) feet it is economical to throw main track to one side and build trestle.

[8]ALLOWANCE FOR SHRINKAGE IN EMBANKMENTS.

For green embankments, shrinkage allowance should be made for both height and width.

The shrinkage allowance should be as follows:

For black dirt, trestle filling: Fifteen (15) per cent.
For black dirt, raising under traffic: Five (5) per cent.
For clay, trestle filling: Ten (10) per cent.
For clay, raising under traffic: Five (5) per cent.
For sand, trestle filling: Six (6) per cent.
For sand, raising under traffic: Five (5) per cent.

[9]GRADE REDUCTION WORK.

(1) Organization.—The simplest organization is preferable. One man should be in responsible charge of the work, with a staff of Engineers and Supervisors to cover the work; the latter should have control of the men, material and means necessary for their respective sections.

(2) The lowest gradient and lightest curvature which physical conditions and the present and prospective business of the railway will warrant should be established.

(3) The location should be completed before entering on the work of construction.

(4) Surface and waterway drainage should be given first consideration, and, lastly, the roadway drainage in excavation.

(5) The grades of railways and highways should be separated wherever practicable.

(6) Temporary bridges should be eliminated by the substitution of permanent structures.

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[8] Adopted, Vol. 8, 1907, pp. 307, 308, 349, 350.
[9] Adopted, Vol. 9, 1908, pp. 608, 609, 642-648; Vol. 16, 1915, pp. 572, 1081.

(7) Light, short haul and preparatory work should be done with teams or other light working plant.

(8) Separate tracks for work and traffic should be provided where conditions warrant.

(9) There should be a well-defined plan for conducting heavy excavation before starting work.

[10]TRACK ELEVATION WORK.

(1) Organization.—A Superintendent of Construction should be in complete charge of the work. The following officers in charge of the various branches of the work should report to him: The Engineers having charge of the contract work and giving lines and grades; the Roadmaster in charge of earth work and track work; the Engineer in charge of masonry and bridges; the Yardmaster in charge of engines and switching. An Assistant Trainmaster, with a Dispatcher, in charge of the operation of traffic over the territory covered by the work in hand, may sometimes be required. If the proportions of the work permit, every person connected with the organization should be relieved from all other duties relating to the operation of the railway.

(2) The railway company should handle with its own forces all work which may interfere with the movement of trains.

(3) As far as practicable, all earth work should be handled by machinery.

(4) The best material for use in filling is that which combines low first cost, ease of handling and stability.

(5) Bridgework, during progress of the work, both railway and highway, should ordinarily consist of temporary bridges, to be replaced by permanent bridges after tracks are elevated or depressed.

(6) Water, sewer and gas pipes, electrical conduits and wires should be cared for and moved by the companies owning them, whether or not the expense is borne by the railway company.

[11]WATERWAYS.

(1) In determining the size of a given waterway, careful consideration should be given to local conditions affecting the safety, economical

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[10] Adopted, Vol. 9, 1908, pp. 591, 631-642; Vol. 16, 1915, pp. 572, 1081.

[11] Adopted, Vol. 10, Part 2, 1909, pp. 920, 921, 967-1022, 1097-1099; Vol. 16, 1915, pp. 572, 1081.

construction and maintenance; chief among these conditions are flood height and flow, size and behavior of other openings in the vicinity carrying the same stream, characteristics of the channel and of the watershed area, climatic conditions, extent and character of traffic on the given line of railway, and probable consequences of interruptions to same.

(2) (a) The practice of using a formula to assist in fixing the proper size of the waterway in a given case is warranted only to the extent that the formula and the values of the terms substituted therein are known to fit local conditions.

(b) Waterway formulas are also useful as a guide in fixing or verifying bridge and culvert areas, where only general information as to local conditions is at hand.

(c) The use of such formulas should not displace careful field observation and the exercise of intelligent judgment on the part of the Engineer.

(d) No single waterway formula can be recommended as fitting all conditions of practice.

[12]SLIDES.

(1) Each slide should be considered as a problem by itself.

(2) The cause of the slide should be sought. The removal or prevention of the cause is as important as the restoration of the roadway.

(3) Piles or retaining walls for the prevention and cure of slides are not recommended; but their use is permissible for temporary repairs and in special cases.

(4) Underground water should be drained away or intercepted before it reaches the slide.

(5) The surface of the slide and the restored roadway should be graded so that water will run off and not lie in pools. The surface may be compacted or sodded.

(6) The flattening of the slope is the most economical and permanent method of curing a sliding embankment.

(7) The weighting of the toe of the slope to restore equilibrium may sometimes be found efficient.

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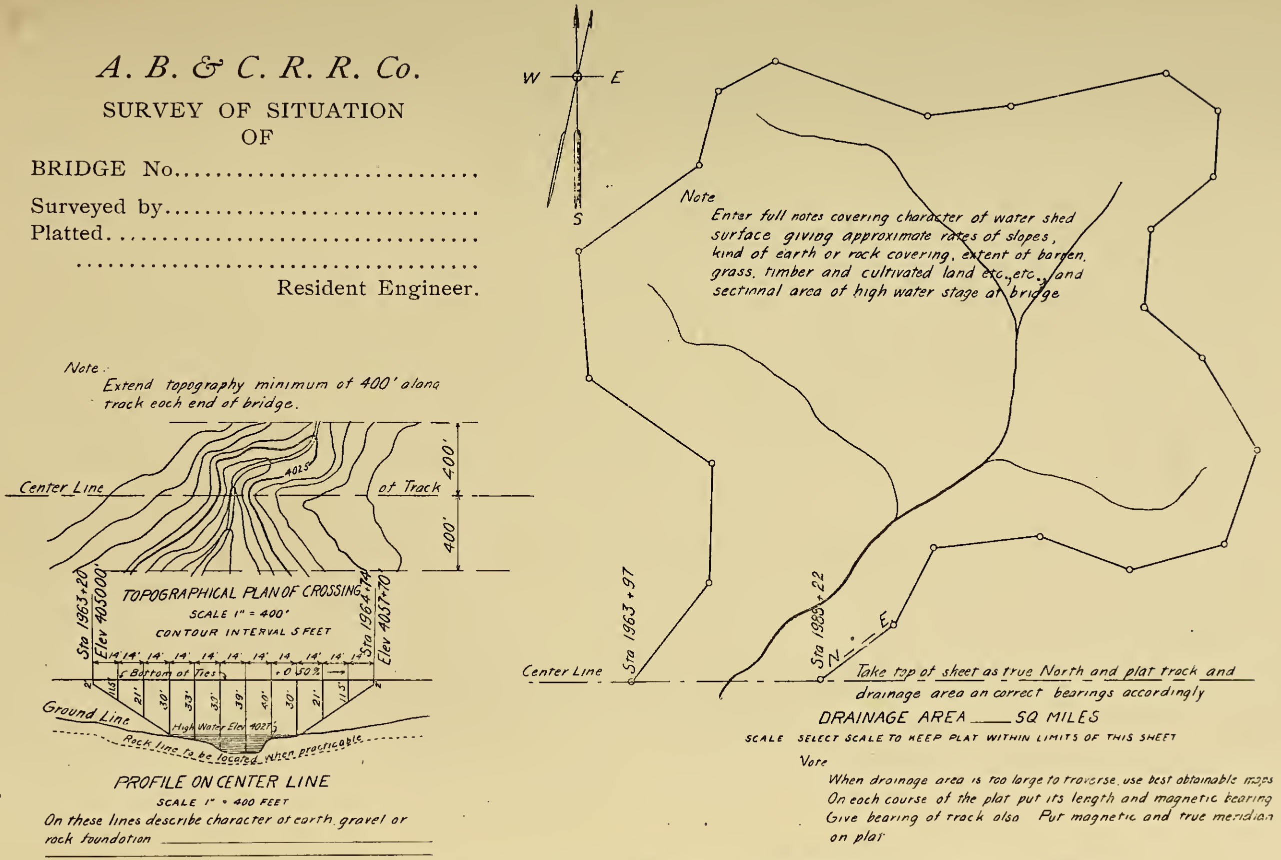
[12] Adopted, Vol. 10, Part 2, 1909, pp. 921, 1023-1093, 1099-1104; Vol. 11, Part 2, 1910, pp. 1064, 1087; Vol. 16, 1915, pp. 572, 1081.



A. B. & C. R. R. Co.

SURVEY OF SITUATION
OF

BRIDGE No.............................

Surveyed by..............................
Platted.......................................
....
Resident Engineer.

Note:
Extend topography minimum of 400' along track each end of bridge.

Note
Enter full notes covering character of water shed surface giving approximate rates of slopes, kind of earth or rock covering, extent of barren, grass, timber and cultivated land etc., etc., and sectional area of high water stage at bridge

Take top of sheet as true North and plat track and drainage area on correct bearings accordingly

DRAINAGE AREA ____ SQ MILES

SCALE SELECT SCALE TO KEEP PLAT WITHIN LIMITS OF THIS SHEET

Note
When drainage area is too large to traverse, use best obtainable maps
On each course of the plat put its length and magnetic bearing
Give bearing of track also Put magnetic and true meridian on plat

TOPOGRAPHICAL PLAN OF CROSSING
SCALE 1" = 400'
CONTOUR INTERVAL 5 FEET

PROFILE ON CENTER LINE
SCALE 1" = 400 FEET

On these lines describe character of earth, gravel or rock foundation ____

Fig. 1. Illustration of Field Observations Necessary for Determining Size of Waterways.

(8) The removal of the material is nearly always the most economical and permanent method of curing a slide in excavation.

(9) A relocation of the line is sometimes necessary where the slide assumes the proportion of an avalanche.

[13]WASHOUTS.

(1) The ends of trestles and bridges should be efficiently protected with masonry, riprap, or other protective work when necessary.

(2) Track should be raised above height of flood waters, if possible, and carried on strong and stable roadbed.

(3) The track on an embankment subject to overflow should be ballasted with heavy angular ballast and anchored. The lower slope of the embankment should be protected with riprap.

(4) Track bridges subject to overflow should be anchored.

(5) If the velocity of the water carries away the riprap or other protection against scour, the width of the opening should be increased.

[14]SURFACE AND SUB-SURFACE DRAINAGE.

(1) Water should be kept off the roadbed if possible.

(2) Intercepting ditches should be constructed for the protection of cuts.

(3) Intercepting ditches or pipe drains should be provided for the protection of banks built on saturated soils.

(4) Side ditches should be constructed in cuts through all classes of materials.

(5) Pipe drains should be provided for the drainage of wet cuts.

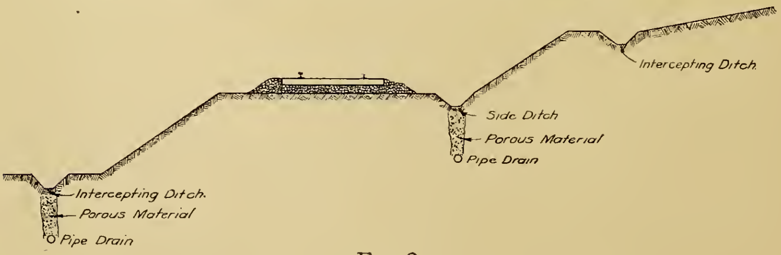


FIG. 2.

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[13] Adopted, Vol. 10, Part 2, 1909, pp. 921, 1023-1093, 1099-1104; Vol. 16, 1915, pp. 572, 1081.

[14] Adopted, Vol. 10, Part 2, 1909, pp. 921, 922, 1094-1096, 1104-1106; Vol. 16, 1915, pp. 573, 1081.

[15]TUNNELS.

(1) The forms and dimensions of the clear space to be provided for single and for double-track tunnels on tangent should conform to the following diagrams (the height of rail in all cases to be assumed as 6 inches):

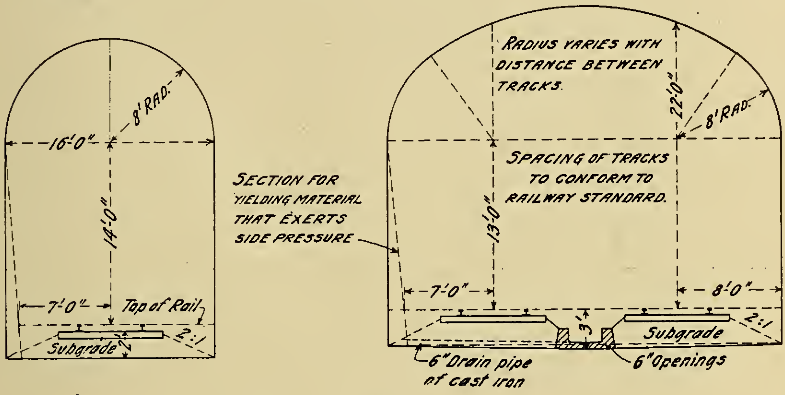
8' RAD.
16'-0"
14'-0"
7'-0"
Top of Rail
2:1
Subgrade
SECTION FOR YIELDING MATERIAL THAT EXERTS SIDE PRESSURE
RADIUS VARIES WITH DISTANCE BETWEEN TRACKS.
22'-0"
8' RAD.
SPACING OF TRACKS TO CONFORM TO RAILWAY STANDARD.
13'-0"
7'-0"
8'-0"
3"
2:1
Subgrade
6" Drain pipe of cast iron
6" Openings

FIG. 3.

(2) The dimensions of the section of tunnels on curved track should be increased and the track placed off the center of tunnel sufficiently to give substantially the clearance given above.

(3) Drainage for a double-track tunnel should occupy a concrete channel midway between the tracks.

(4) Concrete should be used for the permanent tunnel lining, except where local conditions will injure the concrete before it sets.

(5) The arch of every brick-lined tunnel should be laid with vitrified brick in rich Portland cement mortar for a width of five feet on each side of the center line of each track.

[16]TUNNEL CONSTRUCTION.

(1) Railway tunnels, as ordinarily constructed, are more economically built by driving the heading entirely through, first, but such method usually requires a greater length of time for completion of the tunnel.

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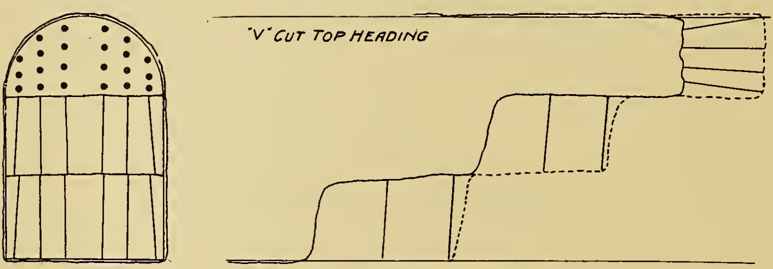
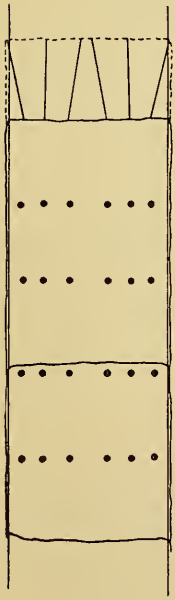
[15] Adopted, Vol. 11, Part 2, 1910, pp. 1065-1097; Vol. 12, Part 3, 1911; Vol. 16, 1915, pp. 573, 1081.

[16] Adopted, Vol. 15, 1914, pp. 392, 1031.

(2) For material requiring support, the top heading should usually be driven.

(3) It is economical and expedient to use an electric shovel or an air-shovel for the removal of the bench, where the section of the tunnel permits the safe operation of the same; and where the material does


SINGLE-TRACK SECTION.



Heading in material of this kind is usually driven by a "V" cut, using from 16 to 22 holes about 8 feet deep. The holes near the middle of the heading are drilled so as to nearly meet at the end. These holes are the first row shot, then the second row and outside holes last. The arrangement of these holes will vary slightly according to the way the material breaks.

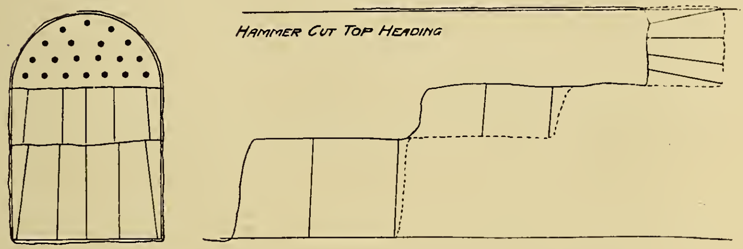
Bench in hard material of this kind is usually taken out in two lifts of almost equal weight. Sub-bench is drilled from 20 to 40 feet in advance of the bench. From 4 to 8 holes in a row, with about 6 to 8-foot face, are used in both sub-bench and bench. One or two rows of holes may be used. Center holes are shot first, round and side holes last.

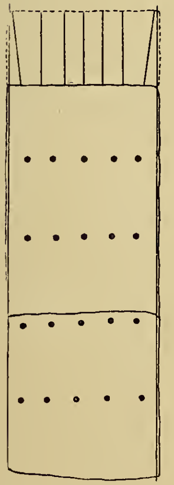
FIG. 4. METHOD OF TUNNEL CONSTRUCTION IN HARD ROCK WITH FEW SEAMS.

not require support there are advantages in low cost and quick removal of the bench in driving the heading at the subgrade line.

(4) Where the time limit is of value, the heading and bench should be excavated at the same time, the heading being kept about 50 feet in advance of the bench. Where the material of the roof is not self-supporting and timbering is to be resorted to, the bench should not be removed until the wall-plates are laid and the arch ribs (or centering) safely put up.

SINGLE-TRACK SECTION.





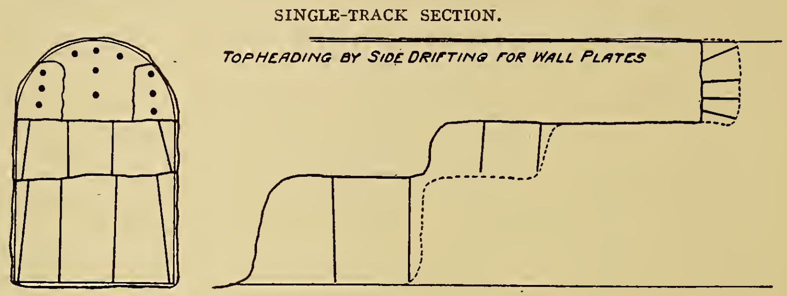
Heading in material of this kind is usually driven by a "hammer cut," using from 14 to 20 holes 6 to 10 feet deep. The bottom row of holes is inclined at about an angle of 30 degrees. The bottom row is shot first and each row shown in succession. These holes should be arranged to suit the seams in the material.

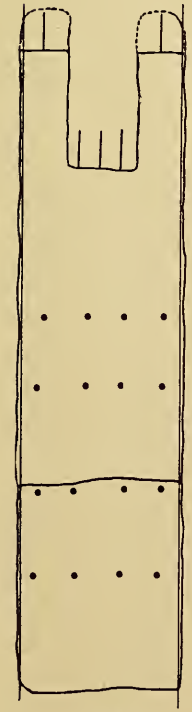
Bench in material of this kind is usually taken out in two lifts, but the sub-bench is not as deep as the bench. Sub-bench is best drilled from 20 to 40 feet in advance of the bench. From 4 to 6 holes in a row may be used with 6 to 10-foot face. The bench is sometimes taken out in one lift. Center holes are shot first, round and side holes last.

Fig. 5. Method of Tunnel Construction in Moderately Hard Rock with Seams.

(5) Opposing grades should preferably not meet between the portals of a tunnel, so as to put a summit in the tunnel, and where practicable, the alinement and ascending grades in the tunnel should be in the same direction as the prevailing winds.

(6) Figs. 4, 5 and 6 are representative of American practice in single-track tunnel construction, where the time limit is of value.





This method is only used when material is so soft that heading cannot be driven for full length of timber used for wall plate. Drifts about 4 feet wide and 6 feet high are driven for each wall plate, and then core is taken out as timber rings are put in. Three or four holes may be used from 3 to 5 feet deep in each drift. The amount of shooting necessary depends entirely upon the softness of the material. It can often be picked. The core may be soft enough to pick, or may be shot with from 4 to 8 holes, either drilled from face as shown or from sides of drifts.

Bench in this class of material is shot in one or two lifts. Very few holes are necessary.

FIG. 6. METHOD OF TUNNEL CONSTRUCTION IN SOFT ROCK OR HARD CLAY.

[17]TUNNEL VENTILATION.

(1) The most practicable, effective and economical artificial ventilation for tunnels carrying steam-power traffic is to be obtained by blowing a current of air into one end of the tunnel for the purpose of removing, or of diluting and removing, the smoke and combustion gases at the opposite end. As practiced in America, this way of procuring ventilation partakes of two methods:

(a) To blow a current of air in the direction the train is moving and with sufficient velocity to remove the smoke and combustion gases ahead of the engine;

(b) To blow a current of air against the direction of the tonnage train with velocity and volume sufficient to dilute the smoke and combustion gases to such an extent as not to be uncomfortable to the operating crews and to clear the tunnel entirely within the minimum time limit for following trains.

[18]SPECIFICATIONS FOR SODDING WITH BERMUDA GRASS.

1. The slopes shall be graded to a uniform surface and all depressions filled in with suitable material and padded down firmly with shovel.

2. If the material of the slope is not fertile it shall be given a dressing of 6 inches of good rich loam. If good loam is not available, a dressing of manure shall be placed on the surface and well raked in. Care, however, shall be taken against the use of such manure as have seeds of objectionable grasses or weeds. Before placing the loam the surface of the slope shall be loosened up roughly to insure a good bond. The surface of the slope to be sodded shall be laid out in shallow horizontal trenches 12 inches apart and three inches deep. The Bermuda sod shall be separated into tufts or small pieces not more than 4 inches square and applied in trenches at intervals of 6 inches to a foot apart, according to quality of sod and character of soil, the object being to place only enough of old sod to furnish enough creeping stems to cover the slope in a reasonably short time, thus creating a new sod on the slope in preference to the old sod. The top of the sod shall not extend above the surface of the slope, and if the season is advanced so that it is liable

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[17] Adopted, Vol. 15, 1914, pp. 339, 1034.
[18] Adopted, Vol. 16, 1915, pp. 594, 1083.

to have hot weather or freezing weather, the sod shall be depressed just below the surface and a covering of loam placed over the soil and loose earth packed firmly around the sod.

3. Sod laid during the day shall be thoroughly watered as soon as practicable after laying and no sod shall be left over night not laid without water. All sod shall be watered daily for 20 days after laying when necessary. On slopes steeper than 2 to 1 the sod shall be in narrow strips 3 to 4 inches wide and 3 feet long and shall be staked to the bank with small stakes 8 inches to a foot long, stakes being placed every foot and a half apart. After the slope has been filled sod shall be rolled or firmly padded down with shovel to a smooth uniform surface. All sod must be taken from good rich soil, be uniform in texture, free from objectionable grasses or weeds and in good healthy condition with no signs of decay and must contain sufficient moisture to maintain its vitality during transportation.

4. Sod shall preferably be cut three feet or more long and eighteen inches to two feet wide and not less than two and one-half inches thick, large pieces of sod being preferable on account of containing their moisture and standing transportation better than small pieces. Sod shall be as fresh as possible and received on the work daily, and any sod to be left over night shall be thoroughly watered; any sod that is heated will not be accepted. All sodding shall be finished before the continued frost sets in.

5. Sod shall be paid for as measured in place, and shall include the entire surface sodded, this price to include furnishing of sod and handling of same. Transportation of sod, men and material also to include stakes where it is necessary to stake the sod. The entire work shall be done in a thorough workmanlike manner to the end that the appearance after completion shall be as nearly as possible that of good natural growth in place.

6. Objectionable grasses and weeds shall be removed from time to time to prevent shading the grasses until such time that the sod has taken hold or the creeping stems have covered the entire slope.

7. Where springs have developed on the slope, a blind drain of cinders or broken stone shall be laid from spring to the toe of the slope.

COMMITTEE II.

BALLAST.

[1]DEFINITIONS.

Ballast.—Selected material placed on the roadbed for the purpose of holding the track in line and surface.

Stone Ballast.—Stone broken by artificial means into small fragments of specified sizes.

Chats.—Tailings from mills in which zinc, lead, silver and other ores are separated from the rocks in which they occur.

Gravel.—Worn fragments of rock, occurring in natural deposits, that will pass through a 2½-inch ring and be retained upon a No. 10 screen.

Sand.—Any hard, granular, comminuted rock which will pass through a No. 10 screen and be retained upon a No. 50 screen.

Chert.—An impure flint or hornstone occurring in natural deposits.

Cinders.—The residue from the coal used in locomotives and other furnaces.

Slag.—The waste product, in a more or less vitrified form, of furnaces for the reduction of ore; usually the product of a blast furnace.

Burnt Clay.—A clay or gumbo which has been burned into material for ballast.

Gumbo.—A term commonly used for a peculiarly tenacious clay, containing no sand.

Disintegrated Granite.—A natural deposit of granite formation, which on removal from its bed by blasting or otherwise, breaks into particles of size suitable for ballast.

Depth of Ballast.—The distance from the bottom of the tie to the top of the subgrade.

[2]CHOICE OF BALLAST.

While there is great variation in the qualities of the different natural materials for ballast, the decision must be as to what is most available or expedient, and should be according to circumstances. Financial questions may be the ruling consideration, or there may be but one material obtainable.

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[1] Adopted, Vol. 5, 1904, pp. 486, 495, 498-501; Vol. 6, 1905, pp. 736, 745; Vol. 7, 1906, pp. 83, 84, 88, 100; Vol. 10, Part 1, 1909, pp. 678, 721-727; Vol. 16, 1915, pp. 1005, 1159.

[2] Adopted, Vol. 5, 1904, pp. 494, 495, 513, 514; Vol. 6, 1905, pp. 736, 737; Vol. 16, 1915, pp. 1006, 1159.

In the case of crushed stone, however, the process of manufacture being under control, it is practicable to make the product conform to specifications.

In the choice of ballast, where possible, gravel should be considered, as it has given excellent results when properly crushed, screened and washed.

[3] PROPER DEPTH OF BALLAST.

From the data available it is concluded that with ties 7 inches by 9 inches by 8½ feet, spaced approximately 24 inches to 25.5 inches, center to center, a depth of 24 inches of stone ballast is necessary to produce uniform pressure on the subgrade, and a combination of a lower layer of gravel or cinder ballast, 18 inches to 14 inches, and an upper layer of stone ballast, 6 inches to 10 inches, approximately 24 inches deep in the aggregate, with the same spacing of the ties, will produce nearly the same results.

[4]SPECIFICATIONS FOR STONE BALLAST.

1. Stone ballast shall be sufficiently durable not to disintegrate in the climate where used, hard enough to prevent pulverizing unduly under the action of tools or traffic, and shall break with an angular fracture when crushed.

2. It shall be broken into pieces of such size that they will in any position pass through a 2½-inch ring and will not pass through a ¾-inch ring.

3. It shall be free from dirt, dust or rubbish.

Attention is called to the physical test of stone for ballast given below, which are recommended as a guide in connection with the specifications.

[5]PHYSICAL TEST OF STONE FOR BALLAST.

It is recommended that the following be used for physical tests of stone ballast. Other things being equal the maximum or minimum results, as indicated, will govern in selecting stone for ballast:

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[3]Adopted, Vol. 13, 1912, pp. 95, 949; Vol. 16, 1915, pp. 1007, 1172.

[4]Adopted, Vol. 5, 1904, pp. 487, 495, 501-505; Vol. 6, 1905, pp. 737, 745; Vol. 11, Part 2, 1910, pp. 907, 930, 931; Vol. 13, 1912, pp. 97, 949; Vol. 16, 1915, pp. 1007, 1159.

[5]Adopted, Vol. 11, Part 2, 1910, pp. 914, 932; Vol. 13, 1912, pp. 98, 99, 950; Vol. 14, 1913, pp. 146, 147, 1078, 1079; Vol. 16, 1915, pp. 1007, 1159.

(a) Weight per cubic foot, maximum.
(b) Water absorption in pounds per cubic foot, minimum.
(c) Per cent. of wear, minimum.
(d) Hardness, maximum.
(e) Toughness, maximum.
(f) Cementing value, minimum.
(g) Compression test, maximum.

The above physical tests are made uniformly and free of charge by the Department of Agriculture, U. S. Government, Washington, D. C. Much valuable information in regard to tests already made and tabulated can also be obtained from this Department.

(For the description of the physical tests of stone for ballast, as recommended by the Association and full instructions as to how the samples should be obtained and shipped to the Government, see Proceedings of the American Railway Engineering and Maintenance of Way Association, Vol. 11, Part 2, pp. 910-914, and report of the Ballast Committee of 1912. If blueprints of the machines used in making the tests are desired they can be obtained from the Department of Agriculture.)

[6]SPECIFICATIONS FOR GRAVEL BALLAST.

For Class A Railways: Bank gravel, which contains more than two (2) per cent. dust or forty (40) per cent. sand, should be washed or screened. Washed or screened gravel should contain not less than twenty-five (25) per cent. nor more than thirty-five (35) per cent. sand.

For Class B Railways: Bank gravel, which contains more than three (3) per cent. dust or sixty (60) per cent. sand, should be screened or washed. Washed or screened gravel should not contain less than twenty-five (25) per cent., nor more than fifty (50) per cent. sand.

For Class C Railways: Any material which makes better track than the natural roadbed may be economically used.

[7]METHOD OF TESTING QUALITY OF GRAVEL FOR BALLAST.

(1) The size of the sample to be tested should be approximately 1 cubic foot.

(2) Five average samples of about 1 cubic foot each should be selected from various parts of the pit which is to be tested. The five

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[6] Adopted, Vol. 11, 1910, pp. 909, 931, 932; Vol. 16, 1915, pp. 1008, 1159.
[7] Adopted, Vol. 14, 1913, pp. 149, 150, 1079-1082; Vol. 16, 1915, pp. 1008, 1159.

samples should then be thoroughly mixed and about 1 cubic foot of the mixture selected for testing.

(3) To separate the gravel from the sand and dust, use a No. 10 screen, ten (10) meshes to the inch, made of No. 24 wire, B. & S. gage. To separate the sand from the dust, use a No. 50 screen fifty (50) meshes to the inch, made of No. 31 wire, B. & S. gage.

(4) Measure the percentage of gravel, sand and dust taken from the sample by volume, giving the percentage of each ingredient compared to the volume of the sum of the ingredients, as follows:

$$\text{Per cent. of sand} = \frac{S}{G+S+D}$$

Where S=Volume of sand.
G=Volume of gravel.
D=Volume of dust.

(5) When sample is shipped for test it should be carefully and securely marked with name and location of the pit from which it was taken.

[8]CINDERS.

Cinder Ballast.

The use of cinders as ballast is recommended for the following conditions: On branch lines with light traffic; on sidings and yard tracks near point of production; as sub-ballast in wet, spongy places; as sub-ballast on new work where embankments are settling, and at places where the track heaves from frost. It is recommended that provision be made for wetting down cinders immediately after being drawn.

[9]SPECIFICATIONS FOR BURNT CLAY BALLAST.

Kind of Material.

1. Good ballast clay is heavy and plastic, free from sand, gypsum or other impurities. It must not crumble when exposed to air or when brought in contact with heat.

Location.

2. The pit should be located on level or moderately sloping ground, not subject to overflow. A water supply is desirable and it should be

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[8] Adopted, Vol. 6, 1905, pp. 737, 738, 745, 746; Vol. 7, 1906, pp. 84, 85, 90, 91, 92, 100; Vol. 16, 1915, pp. 1008, 1159.

[9] Adopted Vol. 6, 1905, pp. 737, 738, 745, 746; Vol. 7, 1906, pp. 84, 85, 90, 91, 92, 100; Vol. 16, 1915, pp. 1009, 1160.

borne in mind that the sulphurous and carbonaceous gases liberated during the burning period damage the surrounding vegetation and make habitation in the near vicinity very disagreeable.

Test.

3. The location site should be thoroughly tested to determine quality of clay, depth and uniform consistency of deposit, and small quantities should be burned in test kilns to show the quality of ballast to be secured.

Burning.

4. Fuel should be fresh, clean slack, and arrangements should be made to secure constant supply. One ton of slack coal is generally sufficient for the perfect burning of four cubic yards of acceptable ballast. From one to one and one-half-inch layer of slack is alternated with from ten to twelve-inch layer of clay, a new layer of slack and clay being applied to the fire every five or six days.

Fires once started must be kept steadily and uniformly burning.

To insure thorough and proper burning of the clay, the top and face of the fire should be frequently raked down, to avoid clinker or black spots, caused by too much or too little air.

When fully burnt a proper ballast clay becomes red in color, when the clay contains iron; when under-burnt the clay will show a yellow color.

Size.

5. Burnt clay ballast should be crushed or broken, if necessary, so that the largest piece will pass through a 4-inch ring.

Density.

6. The finished product should absorb not to exceed 15 per cent. of moisture by weight.

[10]CLEANING FOUL BALLAST.

Under usual conditions no ballast, except stone or hard slag, should be cleaned.

Ballast should be cleaned when foul enough to prevent proper drainage.

Clean with ballast forks or screens.

Clean shoulder down to subgrade.

Clean between ties to bottom of ties.

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[10] Adopted, Vol. 11, Part 2, 1910, pp. 915, 932, 933; Vol. 15, 1914, pp. 969, 1164; Vol. 16, 1915, pp. 1009, 1159.

Clean space between tracks to depth of six (6) inches or more below the bottom of ties.

Clean the berme to bottom of ballast, preferably not less than twelve (12) inches below bottom of tie.

Clean cross ditches between ties approximately every rail length or thirty-three (33) feet. Cross ditches should not be under rail joints.

Return ballast when cleaned and apply sufficient new ballast to produce the standard section.

Tests, fully described in the report of the Committee on Ballast for 1914, indicate stone ballast can be cleaned by use of screens for approximately one-half cost of cleaning stone ballast with forks. (For diagram showing details of collapsible screens, see 1914 report.)

Stone ballast should be cleaned: In terminals, at intervals of one (1) to three (3) years. Heavy traffic, coal and coke lines, at intervals of three (3) to five (5) years. Light traffic lines, at intervals of five (5) to eight (8) years.

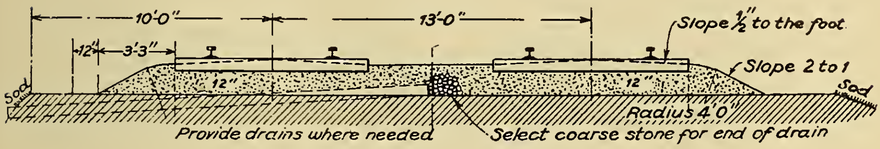
Per cent. of new stone ballast to be applied: Fifteen (15) to twenty-five (25) per cent.

[11]BALLAST SECTIONS.

The following ballast sections illustrate good practice.

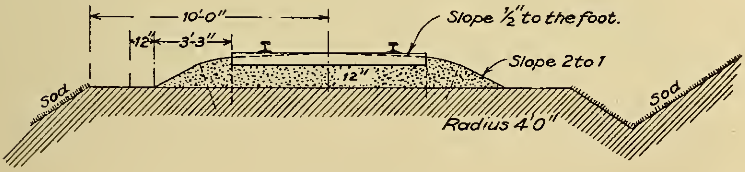
The sections for Class A track are intended to show minimum depth under ties, and are recommended for use only on the firmest, most substantial and well-drained subgrades.

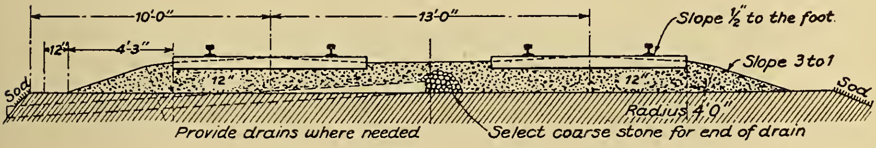
CLASS A.

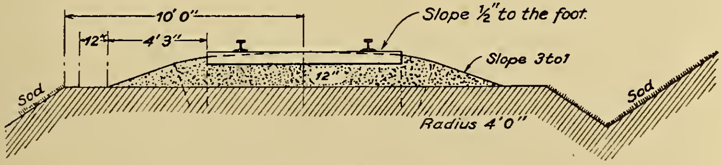


Crushed Stone and Slag.

NOTE—The slag is broken and similar in its character to crushed stone. Granulated slag should be dressed to section shown for Gravel, Cinders and Chats.







Gravel, Cinders and Chats.

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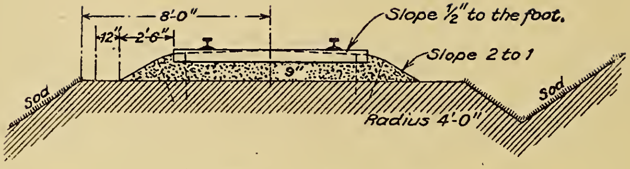
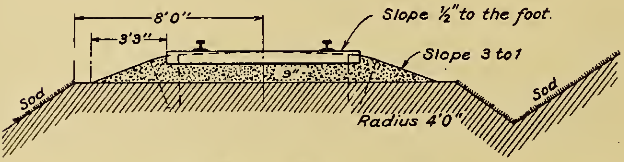
[11]Adopted, Vol. 8, 1907, pp. 44-46, 62, 65, 66, 67; Vol. 9, 1908, pp. 309, 311; Vol. 16, 1915, pp. 1011, 1170.

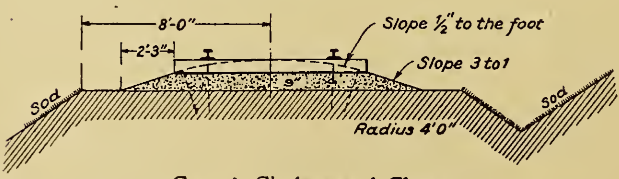
CLASS B.



Crushed Stone and Slag.

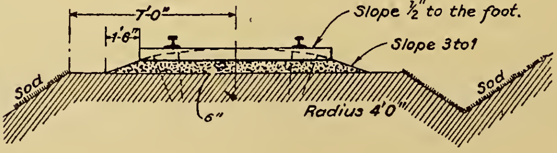


Gravel, Cinders and Chats.

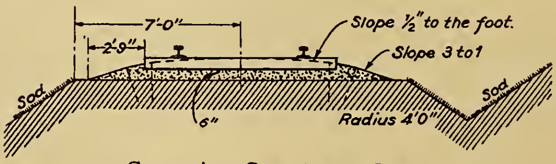


Gravel, Cinders and Chats.

CLASS C.



Cementing Gravel and Chert.



Cementing Gravel and Chert.

COMMITTEE III.

TIES.

[1]DEFINITIONS.

Cross-Tie.—The transverse member of a railway track supporting the rails, by means of which the rails are held in position.

Pole Tie.—A tie made from a tree of such size that not more than one tie can be made from a section; hewed or sawed on two parallel faces.

Split Tie.—A tie made from a tree of such size that by splitting two or more ties can be made from a section.

Slab Tie.—A tie made from the first or outside cut of a log.

Sawed Tie.—A tie having both faces and sides sawed.

Quartered Tie.—A tie made from a tree of such size that four ties only are made from a section.

Half-Round Tie.—A slabbed tie having greater width on lower than on upper face.

Slabbed Tie.—A tie sawed on the faces only.

Hewed Tie.—A tie hewed on at least two sides.

Sap Tie.—A tie which shows more than the prescribed amount of sapwood in cross-section.

Heart Tie.—A tie showing, on one or two corners only, sapwood which does not measure more than one inch on either corner, on lines drawn diagonally across the end of tie.

Strict Heart Tie.—A tie having no sapwood.

Wane Tie.—A squared tie showing part of the original surface of the tree on one or more corners.

Doty Tie.—A tie affected with a fungous disease.

Pecky Tie.—A tie made from a cypress tree affected with a fungous disease, known locally as peck.

Composite Tie.—A tie the essential parts of which are composed of two or more materials.

Concrete Tie.—A tie the essential parts of which are composed of concrete, plain or reinforced.

Cull Tie.—A tie which does not conform to the specifications.

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[1] Adopted, Vol. 5, 1904, pp. 73, 74, 78, 106-120, 131, 132; Vol. 6, 1905, pp. 766, 767; Vol. 7, 1906, pp. 33, 37, 66; Vol. 11, Part 2, 1910, pp. 863, 901; Vol. 16, 1915, pp. 522, 1089.

Head Block.—A tie or ties of a set used to support the switchpoint operating mechanism.

Intermediate Tie.—Any tie used between joint ties.

Joint Tie.—A tie used under a rail joint.

Steel Tie.—A tie the essential parts of which are composed of steel.

Substitute Tie.—Any tie other than a wood tie.

Switch Tie.—A tie of a set used to support a turnout.

Treated Tie.—A tie which has been subjected to a process designed to protect it from decay.

Tapped Tie.—A tie made from a tree, the resin or turpentine of which has been extracted before felling.

Score Mark.—A mark made by the axe as an aid in hewing.

Shakes.—Separations of the wood fiber, due to the action of the wind.

Checks.—Small cracks in the wood due to seasoning.

Face.—The upper or lower plane surface of a tie.

[2]SPECIFICATIONS FOR CROSS-TIES.

Woods to Be Used Untreated.

1. The following woods may be used for tie timber without preservative treatment:

White Oak family.
Longleaf strict heart yellow pine.
Cypress, excepting the white cypress.
Redwood.
White Cedar.
Chestnut.
Catalpa.
Locust, excepting the honey locust.
Walnut.
Black Cherry.

Woods to Be Treated.

2. The following woods shall preferably not be used for tie timber without a preservative treatment approved by the purchaser:

Red Oak family.
Beech.
Elm.

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[2] Adopted, Vol. 5, 1904, pp. 72, 73, 78, 120-132; Vol. 6, 1905, pp. 763-766; Vol. 7, 1906, pp. 34-36, 65, 66.

Maple.

Gum.

Loblolly, shortleaf, Western yellow pine, Norway, North Carolina pine and other sap pines.

Red Fir.

Spruce.

Hemlock.

Tamarack.

Material and Manufacture.

3. Cross-ties shall be well and smoothly hewed or sawed out of straight, growing timber of specified dimensions and out of wind. They shall have sawed ends and straight and parallel faces, the minimum width of either face being not less than that given in the table of dimensions. Bark shall be entirely removed from ties before they are delivered on the Company's ground. They shall be free from splits, shakes, loose or decayed knots, or any other imperfections which may impair their strength or durability.

Dimensions.

4. Except pole ties with rounded sides, or half-round ties, none shall be less than eight (8) inches width of face, and no tie shall be less than six (6) inches thick. A variation in size will be permitted of one-half (½) inch over in thickness, two (2) inches over in width and one (1) inch over in length.

Allowable Variation in Pole Ties.

5. The width of face of pole ties with rounded sides and half-round ties may be less than that given in the table of dimensions, but the least area of cross-section shall be not less than the area corresponding to the tabular dimensions. In no case shall the width of face be less than six (6) inches.

TABLE OF DIMENSIONS.

Class	Thickness by Width of Face	Length		
	Inches	Feet	Feet	Feet
A	7 x 10	8	8½	9
B	7 x 9	8	8½	9
C	7 x 8	8	8½	9
D	6 x 9	8	8½	9
E	6 x 8	8	8½	9

Piling Untreated Ties.

6. Ties which are delivered along the right-of-way of the railway shall be piled at station yards or at points between stations designated in the contract, not less than ten (10) feet from the nearest rail. Each pile shall be of either 25 or 50 ties, built with two ties on the ground and above in alternate courses of 7 and 2, except the top, which shall be placed to form a watershed, as shown in the diagram. Each pile shall be plainly marked with the owner's name and date when piled. Three feet of space shall be left between piles to permit inspection. Sawed ties shall be piled separately from hewed ties.

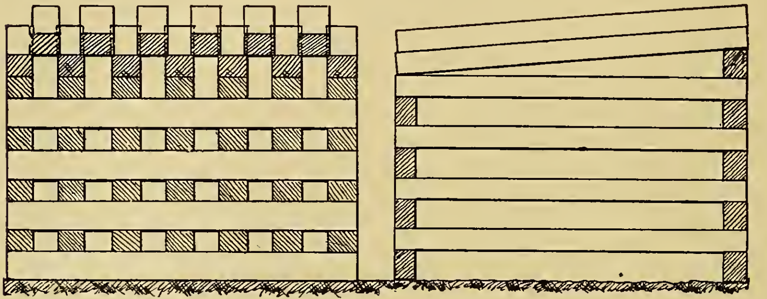
Fig. 1. Piling Diagram for Fifty Ties.

Removal of Rejected Ties.

7. All rejected ties shall be removed from the Company's right-of-way within ten days after notice is given.

Piling Treated Ties.

8. Ties treated with a water solution, as zinc-chloride, particularly red oak and beech ties, shall be piled in close piles on well-drained ground, to prevent checking.

Time of Cutting.

9. Ties shall be cut, as far as possible, in the winter period; that is, from October to March.

[3]CONSERVATION OF TIMBER SUPPLY.

(1) The use of treated ties wherever practicable is recommended.

(2) Ties should be protected from failure against mechanical wear by means of tie plates.

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[3] Adopted, Vol. 10, 1909, pp. 490, 493, 494, 521-528; Vol. 11, 1910, pp. 863, 901; Vol. 16, 1915, pp. 522, 1091.

(3) Tie specifications should be rigidly enforced with particular reference to the exclusion of small ties.

(4) There should be co-operation among the railways in any given territory with a view to the adoption of standard tie specifications, with particular reference to making it impossible for contractors to furnish ties cut from small trees which would naturally form sources for future tie supplies.

(5) Measures should be adopted for reducing forest fires.

(6) Owners should be encouraged to re-forest their lands either by re-planting or natural reproduction.

(7) Proper means should be used to aid in the investigation of tax laws pertaining to forest lands, to obtain legislation which would make it possible to hold growing timber for the purpose of future tie production.

(8) The species of trees to be grown should be selected only after careful and expert study of the available soils and climate.

(9) Plantations should be of such extent as to warrant maintenance appropriations sufficient to insure proper attention.

[4]USE OF DATING NAILS.

(1) A dating nail should be driven in the upper side of every treated tie ten inches inside of the rail on the line side of the track. The tie should be laid with the end having the year stamped on it on the line side of the track. The dating nail should be driven the same day the tie is put in.

(2) Section Foremen should be especially careful to see that marks or nails intended to identify ties are not injured or destroyed.

(3) In addition to the use of the dating nail, each tie should be stamped with the year, at the treating plant, before treatment, and, preferably, should be stamped on both ends.

[5]SPECIFICATIONS FOR DATING NAIL.

Material.

1. The nail shall be made of iron or steel evenly and uniformly galvanized with a coating of zinc. It shall be ¼-inch in diameter, 2½ inches in length, with head ⅝-inch in diameter. Two figures designating the year, the figures to be ⅜-inch in length and depressed into the head $\frac{1}{16}$-inch, shall be stamped therein.

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[4] Adopted, Vol. 7, 1906, pp. 37, 67; Vol. 11, Part 2, 1910, pp. 863, 901.
[5] Adopted, Vol. 7, 1906, pp. 38, 67, 68; Vol. 11, Part 2, 1910, pp. 863, 901.

Test.

2. Any specimen shall be capable of withstanding the following test: The sample shall be immersed in a standard solution of copper sulphate for one minute and then removed, immediately washed in water thoroughly, and wiped dry. This process shall be repeated. If after the fourth immersion there is a copper-colored deposit on the sample, or the zinc has been removed, the lot from which the sample was taken shall be rejected.

Chemicals.

3. The standard solution of copper sulphate shall consist of a solution of 34.5 parts of crystalized copper sulphate in 100 parts of water. This solution shall have a specific gravity of 1.185 at 70 degrees Fahrenheit, and the temperature shall at no time be less than 60 degrees Fahrenheit nor more than 70 degrees Fahrenheit.

[6]TIE RENEWALS IN CONTINUOUS STRETCHES VERSUS SINGLE TIE RENEWALS.

The practice of single tie renewals is recommended.

[7]RECORDS OF CROSS-TIES.

Form M. W. 300 "Foreman's Monthly Tie Removal Report," is recommended as the proper blank to be used by the Section Foreman for reporting the information required for form M. W. 303. This form can also be used for reporting any cross-tie removals when the ties are marked in such a way as to indicate the year laid.

Form M. W. 301, "Statistics of Cross-Tie Removals," is intended for general statistical information concerning the life and cost of cross-ties in use on a division, regardless of the kinds of timber, except in a general way.

Form M. W. 302, "Comparison Between Different Kinds of Wood," is a more detailed comparison between the different kinds of woods and preservative processes. It will explain, in many cases, why the life of ties on one railway is longer than on another.

Form M. W. 303, "Life Record of Ties," gives the life record of ties.

Form M. W. 304, "Statistics of Treated Ties," is intended to give full details concerning the preservation of cross-ties.

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[6] Adopted, Vol. 13, 1912, pp. 342, 959.

[7] Adopted, Vol. 3, 1902, pp. 102-105, 109-113; Vol. 10, Part 1, 1909, pp. 490-492, 521.

FORM M. W. 301.

STATISTICS OF CROSS-TIE RENEWALS.

FORM M. W. 302.

COMPARISON OF DIFFERENT KINDS OF WOOD.

FORM M. W. 303.

LIFE RECORD OF TIES.

FORM M. W. 304.

STATISTICS OF TREATED TIES.

A. B. & C. R. R. CO.

STATISTICS OF CROSS-TIE RENEWALS

Form M. W. 301

For Year Ending________________19____

DIVISION (Report by Division and not by System.)	Miles of Road Operated		No. of Tons Moved One Mile During Year	Maximum Weight in Tons		Weight of Main Track Rail in lbs. per yard	Percentage of Main Track				Kind of Ballast Used. Percentage of Each	Number of Ties in Each Mile of Track		Total Number of Ties Renewed During Year		Per Cent. of Renewals to Number in Tracks			Average Cost Ties Delivered on Ground of Division		*Total Cost of Tie Renewals per Mile of Track			Average Life, Class of Wood and Cost of Cross-Ties.									Climatic Conditions on Division.		
	All Main Tracks	All Tracks Including Sidings		Locomotive and Tender	Fully Loaded Freight Car		Curved	Tie-Plated	Ballasted	Laid with Treated Ties		Main	Side	In Main Tracks	In Side Tracks	Main	Side	Total	Treated Ties	Untreated Ties	All Main Tracks	All Side Tracks	All Tracks	Main Tracks			Side Tracks			All Tracks			Temperature		Approx. Rainfall in Inches
																								Life	Class	Cost	Life	Class	Cost	Life	Class	Cost	Max.	Min.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Total for Year																																			
Total for Previous Year																																			

*To include cost of cross and switch ties, tie-plates, and spike plugs, but not the labor of placing in track. Data for columns 25 to 33 kept on Forms M. W. 302 and 303.

Omit mileage of new tracks in which tie renewals have not been commenced, and omit number of ties used for new tracks. Bridge ties are to be considered as track ties and included in report.

Tons of 2,000 lbs. to be used.

A. B. & C. R. R. CO.

COMPARISON OF DIFFERENT KINDS OF WOOD

Form M. W. 302

For Year Ending________________19____

DIVISION (Report by Division and not by System.)	UNTREATED																					TREATED															Grand Totals			No. of Tie-plated Ties included in totals
	White Oak, Burr Oak, Chestnut Oak			Chestnut			Pine			Cedar			Cypress			Other Woods			Totals			Process			Process			Process			Process			Totals						
	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Totals																																								

This blank elaborates the information in columns 25 to 33 of Form M. W. 301 and compares the value of the different woods as ties, irrespective of cost. See Form M. W. 304 for detail information concerning "preserved" or "treated" ties.

Do not include ties in new tracks in which renewals have not yet commenced. If the headings given do not cover the kind of ties used, change them.

Form M. W. 303.

A. B. & C. R. R. CO.

RECORD OF TIES

Data completed to________________19____

			Total Number of the Cross-Ties Stamped for the Year in Column 1 Removed from Tracks in the Year in Columns 4 to 57 (both inclusive).																																																											
Total Cross-Ties, all kinds, laid in Track. (inc. new track.)			Year.						Year.						Year.						Year.						Year.						Year.						Year.						Year.						Year.						Total Removed.		Per cent. remaining in track on date of this report.		Average Life in years deduced from renewals.	
Year	Main	Side	Main			Side			Main			Side			Main			Side			Main			Side			Main			Side			Main			Side			Main			Side			Main			Side			Main			Side			Main	Side	Main	Side	Main	Side
			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63

This blank cannot be tabulated for several Divisions or Railroads. It must be presented for each separately, but will only be printed when considered sufficiently complete. When records have not been kept so that this can be filled out for a single year, the blank should be returned to the Secretary marked "No Data." In course of time it will be a valuable blank to all, and will be easily kept when once started. This blank furnishes the data for columns 25 to 33 of Form 1. In body of blank causes for increased or decreased life of ties as years advance should be explained. In body of blank kinds of timber used for ties and approximate percentage of each kind should be stated. Records should start with year 1888 ties, if possible; otherwise as far back as records will permit.

NOTE.—Class L includes:
White Oak Family.
Chestnut.
Tamarack.
Cedar.
Locust.
Cypress.
Long Leaf Yellow Pine.
Redwood.
Catalpa.
Cherry.

Class S includes:
All Pine except Long Leaf.
Beech.
Elm.
Gum.
Inferior Oaks.
Hemlock.
Red Fir.
Spruce.

Class T includes—All classes of Treated Ties.

Form M. W. 304

A. B. & C. R. R. CO.

STATISTICS OF TREATED TIES

For Year Ending________________19____

DIVISION (Report by Division and not by System.)	LIFE OF TREATED TIES IN YEARS																														Antiseptic Used	Amount Injected per Cubic Foot	Number of Treated Ties in Track this Date	Number put in Tracks this Year	Average Cost per Tie				Remarks
	Pine					Hemlock					Beech					Spruce																			First Cost Untreated	For Extra Handling and Transportation	For Preservative Treatment	Ready for Track	
	Process					Process					Process					Process					Process					Process													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40

The life record of treated ties should be kept separately on a blank like Form M. W. 303.

Size, 8x13 inches. Form M. W. 300.

A., B. & C. R. R. Co.

FOREMAN'S MONTHLY TIE REMOVAL REPORT

Section No.................. Division................ Month of.....................19....

Removed from Main Tracks					Removed from Side Tracks			
Number Removed	Year Put in	Kind of		Cause	Number Removed	Year Put in	Kind of	
		Timber	Treatment*				Timber	Treatment*

After approval by..........................it is to be forwarded to.....................

....

Foreman.

This blank must be sent in monthly by all Foremen, whether any ties have been removed or not. When no ties have been removed, it must be so stated on the blank.

*Note.—When untreated ties are removed, make a dash (—) in "Treatment" column.

[8]ECONOMIC COMPARISON OF CROSS-TIES OF DIFFERENT MATERIALS.

Except in isolated cases, ultimate economy in labor and material results from the use of properly treated ties, as compared with untreated ties.

The economy of any tie of known price and life may be determined by the following formulas:

Given:

C = First Cost of tie;

C^1 = Amount of Compound Interest which will produce interest equalling first cost of tie, during life of tie.

R = Rate of interest.

n = Life of tie in years.

Required—Total capitalization of tie:

$$= C + C^1 = \frac{C(1+R)^n}{(1+R)^n - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

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[8] Adopted, Vol. 16, 1915, pp. 524, 1091.

Given:

C = First cost of tie.

R = Rate of interest.

I = Interest on first cost.

A = Amount at compound interest which will provide for renewal at end of life of tie.

Required—Total annual cost:

$$I = CR$$

$$A = \frac{CR}{(1+R)^n - 1}$$

Total annual cost =

$$I + A = \frac{CR\,(1+R)^n}{(1+R)^n - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Given:

R = Rate of interest.

C = Cost of tie of n years life.

C^1 = Cost of tie of n^1 years life.

Tie costs are equivalent when the capitalization or annual costs are equal, or—

$$C^1 = \frac{C(1+R)^n}{(1+R)^n - 1} \times \frac{(1+R)^{n^1} - 1}{(1+R)^{n^1}} \quad \ldots\ldots\ldots\ldots (3)$$

COMMITTEE IV.

RAIL.

[1]SPECIFICATIONS FOR CARBON STEEL RAILS—1915.

INSPECTION.

Access to Works.

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the rails have been made and loaded in accordance with the terms of the specifications.

Place for Tests.

2. All tests and inspections shall be made at the place of manufacture, prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

MATERIAL.

Material.

3. The material shall be steel made by the Bessemer or Open-Hearth process as provided by the contract.

CHEMICAL REQUIREMENTS.

Chemical Composition.

4. The chemical composition of each heat of the steel from which the rails are rolled, determined as prescribed in Section 6, shall be within the following limits:

Elements	Per Cent. for Bessemer Process		Per Cent. for Open-Hearth Process	
	70 lbs. and over but under 85 lbs.	85-100 lbs. inclusive	70 lbs. and over but under 85 lbs.	85-100 lbs. inclusive
Carbon	0.40 to 0.50	0.45 to 0.55	0.53 to 0.66	0.62 to 0.75
Phosphorus, not to exceed	0.10	0.10	0.04	0.04
Manganese	0.80 to 1.10	0.80 to 1.10	0.60 to 0.90	0.60 to 0.90
Silicon, not less than.	0.10	0.10	0.10	0.10

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[1] Adopted, Vol. 3, 1902, pp. 204, 208; Vol. 5, 1904, pp. 465, 469; Vol. 6, 1905, p. 190; Vol. 7, 1906, pp. 549, 552, 559, 562, 573, 576; Vol. 10, Part 1, 1909, pp. 374, 393; Vol. 11, Part 1, 1910, pp. 237, 252, 255; Vol. 12, Part 1, 1911, p. 467; Vol. 12, Part 2, 1911, p. 12; Vol. 13, 1912, pp. 853, 1017; Vol. 14, 1913, pp. 181, 1103; Vol. 15, 1914, pp. 158, 375, 1104; Vol. 16, 1915, pp. 157, 159, 1117.

When other acceptable deoxidizing agents are used, the minimum limit for silicon will be omitted.

Average Carbon.

5. It is desired that the percentage of carbon in an entire order of rails shall average as high as the mean percentage between the upper and lower limits specified.

Analyses.

6. In order to ascertain whether the chemical composition is in accordance with the requirements, analyses shall be furnished as follows:

(a) For Bessemer process the manufacturer shall furnish to the inspector, daily, carbon determinations for each heat before the rails are shipped, and two chemical analyses every twenty-four hours representing the average of the elements, carbon, manganese, silicon, phosphorus and sulphur contained in the steel, one for each day and night turn respectively. These analyses shall be made on drillings taken from the ladle test ingot not less than one-eighth inch beneath the surface.

(b) For Open-Hearth process, the makers shall furnish the inspectors with a chemical analyses of the elements, carbon, manganese, silicon, phosphorus and sulphur, for each heat.

(c) On request of the inspector, the manufacturer shall furnish a portion of the test ingot for check analyses.

PHYSICAL REQUIREMENTS.

Physical Qualities.

7. Tests shall be made to determine:

(a) Ductility or toughness as opposed to brittleness.

(b) Soundness.

Method of Testing.

8. The physical qualities shall be determined by the Drop Test.

Drop Testing Machine.

9. The drop testing machine used shall be the standard of the American Railway Engineering Association.

(a) The tup shall weigh 2000 lbs., and have a striking face with a radius of five inches.

(b) The anvil block shall weigh 20,000 lbs., and be supported on springs.

(c) The supports for the test pieces shall be spaced three feet between centers and shall be a part of, and firmly secured to, the anvil. The bearing surfaces of the supports shall have a radius of five inches.

Pieces for Drop Test.

10. Drop tests shall be made on pieces of rail not less than four feet and not more than six feet long. These test pieces shall be cut from the top end of the top rail of the ingot, and marked on the base or head with gage marks one inch apart for three inches each side of the center of the test piece, for measuring the ductility of the metal.

Temperature of Test Pieces.

11. The temperature of the test pieces shall be between 60 and 100 degrees Fahrenheit.

Height of Drop.

12. The test piece shall preferably be placed base upwards on the supports, and be subjected to impact of the tup falling free from the following heights:

For 70-lb. rail	16 feet
For 80, 85 and 90-lb. rail	17 feet
For 100-lb. rail	18 feet

Elongation or Ductility.

13 (a) Under these impacts the rail under one or more blows shall show at least 6 per cent. elongation for one inch, or 5 per cent. each for two consecutive inches of the six-inch scale, marked as described in Section 10.

(b) A sufficient number of blows shall be given to determine the complete elongation of the test piece of at least every fifth heat of Bessemer steel, and of one out of every three test pieces of a heat of Open-Hearth steel.

Permanent Set.

14. It is desired that the permanent set after one blow under the drop test shall not exceed that in the following table, and a record shall be made of this information:

Rail			Permanent Set, measured by Middle Ordinate in Inches in a Length of 3 Feet	
Section	Weight per Yard	Moment of Inertia	Bessemer Process	Open-Hearth Process
A.R.A.-A.	100	48.94	1.65	1.45
A.R.A.-B.	100	41.30	2.05	1.80
A.R.A.-A.	90	38.70	1.90	1.65
A.R.A.-B.	90	32.30	2.20	2.00
A.R.A.-A.	80	28.80	2.85	2.45
A.R.A.-B.	80	25.00	3.15	2.85
A.R.A.-A.	70	21.05	3.50	3.10
A.R.A.-B.	70	18.60	3.85	3.50

Test to Destruction.

15. The test pieces which do not break under the first or subsequent blows shall be nicked and broken, to determine whether the interior metal is sound. The words "interior defect," used below, shall be interpreted to mean seams, laminations, cavities or interposed foreign matter made visible by the destruction tests, the saws or the drills.

Bessemer Process Drop Tests.

16. One piece shall be tested from each heat of Bessemer steel.

(a) If the test piece does not break at the first blow and shows the required elongation (Section 13), all of the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(b) If the test piece breaks at the first blow, or does not show the required elongation (Section 13), or if the test piece does not break and shows the required elongation, but when broken shows interior defect, all of the top rails from that heat shall be rejected.

(c) A second test shall then be made of a test piece selected by the inspector from the top end of any second rail of the same heat, preferably of the same ingot. If the test piece does not break at the first blow, and shows the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(d) If the test piece breaks at the first blow, or does not show the required elongation (Section 13), or if the test piece does not break and shows the required elongation, but when broken shows interior defect, all of the second rails from that heat shall be rejected.

(e) A third test shall then be made of a test piece selected by the inspector from the top end of any third rail of the same heat, preferably of the same ingot. If the test piece does not break at the first blow and shows the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(f) If the test piece breaks at the first blow, or does not show the required elongation (Section 13), or if the test piece does not break and shows the required elongation, but when broken shows interior defect, all of the remainder of the rails from that heat shall be rejected.

Open-Hearth Process Drop Tests.

17. Test pieces shall be selected from the second, middle and last full ingot of each Open-Hearth heat.

(a) If two of these test pieces do not break at the first blow, and if both show the required elongation (Section 13), all of the rails of the heat shall be accepted, provided that none of the three test pieces when broken show interior defect.

(b) If two of the test pieces break at the first blow, or do not show the required elongation (Section 13), or if any of the three test pieces when broken show interior defect, all of the top rails from that heat shall be rejected.

(c) Second tests shall then be made from three test pieces selected by the inspector from the top end of any second rails of the same heat, preferably of the same ingots. If two of these test pieces do not break at the first blow and if both show the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that none of the three test pieces when broken show interior defect.

(d) If two of these test pieces break at the first blow, or do not show the required elongation (Section 13), or if any of the three test pieces when broken show interior defect, all of the second rails of the heat shall be rejected.

(e) Third tests shall then be made from three test pieces selected by the inspector from the top end of any third rails of the same heat, preferably of the same ingots. If two of these test pieces do not break at the first blow, and if both show the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that none of the three test pieces when broken shall show interior defect.

(f) If two of these test pieces break at the first blow, or do not show the required elongation (Section 13), or if any of the three test pieces when broken show interior defect, all of the remainder of the rails from that heat shall be rejected.

No. 1 Rails.

18. No. 1 classification rails shall be free from injurious defects and flaws of all kinds.

No. 2 Rails.

19. (a) Rails which by reason of surface imperfections, or for causes mentioned in Section 29 hereof, are not classed as No. 1 rails, will be accepted as No. 2 rails, but No. 2 rails which contain imperfections in such number or of such character as will, in the judgment of the inspector, render them unfit for recognized No. 2 uses, will not be accepted for shipment.

(b) No. 2 rails to the extent of 5 per cent. of the whole order will be received. All rails accepted as No. 2 rails shall have the ends painted white and shall have two prick punch marks on the side of the web near the heat number near the end of the rail, so placed as not to be covered by the joint bars.

DETAILS OF MANUFACTURE.

Quality of Manufacture.

20. The entire process of manufacture shall be in accordance with the best current state of the art.

Bled Ingots.

21. Bled ingots shall not be used.

Discard.

22. There shall be sheared from the end of the bloom, formed from the top of the ingot, sufficient metal to secure sound rails.

Lengths.

23. The standard length of rails shall be 33 feet, at a temperature of 60 degrees Fahrenheit. Ten per cent. of the entire order will be accepted in shorter lengths varying by 1 foot from 32 feet to 25 feet. A variation of one-fourth inch from the specified lengths will be allowed, excepting that for 15 per cent. of the order a variation of 3/8 inch from the specified lengths will be allowed. No. 1 rails less than 33 feet long shall be painted green on both ends.

Shrinkage.

24. The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass, the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws, for a rail 33 feet in length and of 100-lb. section, of six and three-fourths inches and one-eighth inch less for each ten lbs. decrease in section.

Cooling.

25. The bars shall not be held for the purpose of reducing their temperature, nor shall any artificial means of cooling them be used after they leave the finishing pass. Rails, while on the cooling beds, shall be protected from snow and water.

Section.

26. The section of rails shall conform as accurately as possible to the template furnished by the Railroad Company. A variation in height

of one-sixty-fourth inch less or one-thirty-second inch greater than the specified height, and one-sixteenth inch in width of flange, will be permitted; but no variation shall be allowed in the dimensions affecting the fit of the joint bars.

Weight.

27. The weight of the rails specified in the order shall be maintained as nearly as possible, after complying with the preceding Section. A variation of one-half of 1 per cent. from the calculated weight of section, as applied to an entire order, will be allowed.

Payment.

28. Rails accepted will be paid for according to actual weights.

Straightening.

29. (a) The hot straightening shall be carefully done, so that gagging under the cold presses will be reduced to a minimum. Any rail coming to the straightening presses showing sharp kinks or greater camber than that indicated by a middle ordinate of 4 inches in 33 feet, for A. R. A. type of sections, or 5 inches for A. S. C. E. type of sections, will be at once classed as a No. 2 rail. The distance between the supports of rails in the straightening presses shall not be less than 42 inches. The supports shall have flat surfaces and be out of wind.

(b) Rails heard to snap or check while being straightened shall be at once rejected.

Drilling.

30. Circular holes for joint bolts shall be drilled to conform to the drawing and dimensions furnished by the Railroad Company.

Finishing.

31. (a) All rails shall be smooth on the heads, straight in line and surface, and without any twists, waves or kinks. They shall be sawed square at the ends, a variation of not more than one-thirty-second inch being allowed; and burrs shall be carefully removed.

(b) Rails improperly drilled or straightened, or from which the burrs have not been removed, shall be rejected, but may be accepted after being properly finished.

(c) When any finished rail shows interior defects at either end or in any drilled hole, the entire rail shall be rejected.

Branding.

32. Rails shall be branded for identification in the following manner:

(a) The name of the manufacturer, the month and year of manufacture, and the weight and type of section of rail shall be rolled in raised letters and figures on the side of the web. The type shall be marked by letters which signify the name by which it is known, as for example:

Sections of American Society of Civil Engineers..............A. S. C. E.
Sections of American Railway Association............R. A.-A., R. A.-B.
Sections of American Railway Engineering Association............R. E.

(b) The number of the heat and letter indicating the portion of the ingot from which the rail was made shall be plainly stamped on the web of each rail where it will not be covered by the joint bars. The top rails shall be lettered "A" and the succeeding ones "B," "C," "D," etc., consecutively; but in case of a top discard of from 20 to 35 per cent. the letter "A" will be omitted, the top rail becoming "B". If the top discard be greater than 35 per cent. the letter "B" shall be omitted, the top rail becoming "C".

(c) Open-Hearth rails shall be branded or stamped "O-H" in addition to other marks.

(d) All markings of rails shall be done so effectively that the marks may be read as long as the rails are in service.

Separate Classes.

33. All classes of rails shall be kept separate from each other.

Loading.

34. Rails shall be carefully handled and loaded in such manner as not to injure them.

RAIL SECTIONS.

The railroad, as we know it to-day, dates back to about the year 1830, and the question of a proper rail section has been the subject of almost continuous study and development since that time.

The rail section in common use in the United States and Canada is the so-called "flat bottom" pattern designed by Colonel Robert L. Stevens in 1830. As a matter of history it is interesting to note that five hundred rails, eighteen feet long, 36 lbs. to the yard, designed by Colonel Stevens and rolled by the Dowlais Iron Works, Cardiff, Wales, were shipped to Philadelphia in the year 1831, and laid the same year on the Camden & Amboy Railroad, now a part of the Pennsylvania Railroad System.

In introducing a new series of rail sections for use in the United States and Canada, it is not thought necessary to refer to the discussions in other countries, nor to those in the technical papers of this country, but it will be interesting to review the principal former discussions in this country. Those further interested in the subject will find valuable information in the Proceedings of the Institution of Civil Engineers (England), the Bulletin and Proceedings of the International Railway Congress Association, and the Report of the Engineering Standards Committee (England). The work of Baron von Weber on the "Stability of the Track," translated into English and published in the Engineering (London) from July to December, 1870, should not be overlooked; also the interesting paper of Henry G. Prout on the development of the steel rail in the United States, published in the Engineering Magazine, July and August, 1897. Reference should also be made to the sections adopted by the Manufacturers' Committee of this country at the meeting of May 16, 1911.

(1) THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The subject of rail sections was considered by this Society from 1873 to 1910, during which time some of the most prominent engineers of the country took part in the discussions.

A Committee was appointed January, 1873, "On the Form, Weight, Manufacture, and Life of Rail." This Committee submitted its first report in 1874, a second report in 1875, and a final report in 1876 (Transactions A.S.C.E., Vol. III, page No. 87; Vol. IV, page No. 136; and Vol. V, page No. 327).

At its convention June, 1885, it adopted the following resolution:

"WHEREAS, the relation which the form of head of a rail should bear to the section of a car wheel tread and flange has recently been in dispute, it being asserted, on the one hand, that they should have as long a line of contact as possible, and, on the other hand, that such long contact would be dangerous and injurious, and

"WHEREAS, the question raised by this diversity of view is of direct importance to the many members of this Society, as well as to the public interest, and hence is one which this Society may appropriately consider through committee; therefore be it

"*Resolved,* that a committee of five members of this Society be appointed by the President to consider and report to the Society on the proper relation to each other of the sections of rails and wheels; to what extent and at what points it is expedient that their sections be such as to bring them normally in contact, and to what extent and at what points it is not expedient that they should be so in contact; and that the Committee be instructed to seek information from all those who are known to have given the subject attention."

A preliminary report was made in 1888, and a final report in 1889 (Transactions A.S.C.E., Vol. XIX, page No. 1; and Vol. XXI, page No. 223). The convention in 1889 desired that the Committee be continued and be requested to consider the standard forms of rail sections. Owing, however, to a constitutional requirement it was found necessary to discharge that and appoint a new one. At the Society meeting of January, 1890, the new Committee was announced, the personnel of which included all the members of the preceding Committee with some additions. A progress report was made in 1891, and a final report in 1893 (Transactions A.S.C.E., Vol. XXIV, page No. 1, and Vol. XXVIII, page No. 425). The sections reported and adopted became the standards for the majority of the railroads of the country.

In 1902 a Special Committee was appointed to review the former work of the Society. The Committee reported in 1905 upon the results obtained by seventy-nine of the leading railroads of the United States and Canada from the use of the American Society sections, which indicated that the Society sections were standard on forty-eight roads and that sixty-three roads intended to use them as standard. The report concluded as follows:

"Rails of heavier sections are not giving service expected of them even after making due allowance for increased traffic tonnage or for the trouble caused by badly balanced driving wheels and poor condition of rolling stock and roadbed, but after due consideration of all information collected, your Committee does not feel justified in now recommending any modification of the sections."

The final report of this Committee was made in 1910 (Transactions A.S.C.E., Vol. LXX, page No. 456).

(2) AMERICAN INSTITUTE OF MINING ENGINEERS.

Several important papers read before the American Institute of Mining Engineers should be noted.

From one of these on "Rail Patterns," by A. L. Holley, C. E., LL. D., read before the Institute at Philadelphia, in February, 1891, the object of which, as stated by him, was, first, to show that the multiplication of rail patterns was not only an annoyance and an expense to rail makers, but a source of immense loss to railway companies; and, second, to review the suggestions of experiment and practice regarding the shape of steel rails, and to suggest a method for the adoption of the few standard patterns which are necessary, we quote the following as being of interest in showing the conditions existing at that time:

> "There are regularly manufactured in the eleven Bessemer steel rail mills of the United States, 119 patterns (from all the works 188 patterns were sent to me as standard. Of these I found 119 different shapes and 69 duplicates) of steel rails, of 27 different weights per yard. This list does not include patterns which, although still largely in use, are regarded by experts as obsolete, and which would swell the number to nearly 300; nor does it include all the patterns for which rolls are kept on hand to fill a possible demand; nor does it include extra patterns rolled in one finishing groove by opening and closing the rolls so as to get different weights with the same contours. The list embraces only those separate patterns which are subject to current orders. How thoroughly modern these patterns are, is shown by the fact that of the whole 119, there are but five patterns of conspicuously bad shape; all the rest more or less completely illustrate the standard features—a heavy head, light web and flanges, and a good angle to hold the fish-plates. Sixty-two per cent. of the patterns have the "Chanute" head, which was not designed until 1874. Sixty-four per cent. of the 119 patterns were embraced under five weights per yard; three only of these vary from standard type; there are thus left 76 patterns, all of the modern and standard, to represent five different weights, for which five patterns would perfectly answer. Of the 60-lb. rails, there is only one of the pear-head type, while a dozen of the beveled head templets cannot be distinguished from each other except by laying them together; and yet no less than 30 patterns are in current use for the 60-lb. weight, which is obviously 29 patterns too many." (Proceedings A.I.M.E., Vol. IX, pages Nos. 360 and 529 [1881].)

The following is a quotation from a paper on "Rail Sections" by W. F. Mattes, Chief Engineer of the Lackawanna Iron and Steel Works, Scranton, read before the Institute at Scranton, in February, 1887: "The manufacture of steel rails in the United States upon a large scale may be roughly dated from the years 1875-76, and the same years witnessed an active movement among the railroads toward the adoption of heavier and improved patterns. In this movement each road was a law unto itself, and the "personal equations" of some scores of engineers were so freely injected into the calculations that patterns were multiplied in the most absurd and mischievous manner, until at length the burden upon the mills became well nigh unendurable, and called forth a vigorous protest in Mr. Holley's paper read before the Institute in February, 1881." (Proceedings A.I.M.E., Vol. XV, page No. 776 [1887].)

For further references see papers on "Rail Sections," "Proposed Rail Sections" and "A System of Rail Sections in Series" presented respectively by Mr. F. A. Delano, Captain Robert W. Hunt, and Doctor P. H. Dudley. (Proceedings A.I.M.E., XVII, page No. 421 [1889]; XVII, page No. 778 [1889]; and Vol. XVIII, page No. 763 [1890].)

(3) THE AMERICAN RAILWAY ASSOCIATION.

The subject of standard rail and wheel sections was brought to the attention of The American Railway Association by its Executive Committee at a meeting held in Chicago, October, 1905, in the following manner:

"A suggestion has been made that the Association should appoint a Committee on the subject of Standard Rail and Wheel Sections. Conditions have materially changed since the sections formerly considered as standards were adopted. Certain technical organizations may suggest one or the other of these standard sections, but as the relations between them are of great importance, it has been thought that this Association by securing the co-operation of the others, could arrive at the most favorable results.

"Your Committee, therefore, suggests the consideration of the following resolution:

"Resolved, That a Committee of nine persons be appointed by the President as a Committee on Standard Rail and Wheel Sections; this Committee to include the members of such other technical organizations whose co-operation the President may deem desirable in securing the best results."

This resolution was adopted and a committee appointed which had the co-operation and assistance of the manufacturers.

A preliminary report was submitted at the meeting held in October, 1906, from which the following is quoted:

"A preliminary investigation of the subject developed the fact that certain changes in the contour of the present standard car wheel were under consideration, and that these changes were of such a character as to require consideration of their effect on certain existing track standards.

"The Master Car Builders' Association has changed the standard wheel from time to time, increasing the weight and section to meet the demand of increasing wheel loads, but the flange dimensions has remained constant for some years, owing to its relation to certain fixed standards for frog and guard rail clearance.

"Your Committee is not yet ready to recommend the adoption of the proposed wheel section in its entirety as a permanent standard, as it feels that further consideration should be given to the question of relationship between the wheel and rail, especially in the matter of throat radius and tread coning.

"The subject of rail sections has been gone into far enough to ascertain that no such emergency exists as was found with respect to the wheel section. Existing standards are giving fair satisfaction, but wide difference of opinion seem to exist on various points of detail. The question is being considered by a number of technical societies, and until an opportunity can be had to review the work of these various bodies, your committee can only report progress.

"The question as to whether or not the consideration of the rail section should also include consideration of specifications for rail manufacture has been raised by some of the members, and your committee would be glad to have instructions on this point. It seems to be the general feeling that improvement in the quality of the material in steel rails is of vastly greater importance than improvement in the section."

The following is from the Committee's final report made in March, 1909:

"Your Committee respectfully recommends that the series of sections of types "A" and "B" and the specifications for Bessemer and Open-Hearth steel rails, submitted with this report, be adopted as the recommended practice of the Association and that the sections and specifications be referred to the American Railway Engineering and Maintenance of Way Association, with the request that they follow up the question of determining the details as to drop test, etc., by observing the actual results of rails rolled under the new sections, and that they also arrange to collect from the different members and tabulate all information as to comparative wear of rails rolled from the different parts of the ingot, and all other information necessary to a proper study of the problem. That they may be further requested to keep careful record of the comparative results in service of rails of types "A and "B," and to prepare and submit to this Association a single type of section which will embody their ideas as to the best type that can be designed for use as a single standard to be adopted by this Association, giving due weight to every factor entering into the problem." (Proceedings A.R.A., March, 1909, page No. 315.)

The American Railway Association concurred in the recommendation of its Committee, and the general subject of specifications for Bessemer and Open-Hearth steel rails, as well as that of rail sections, was referred to the American Railway Engineering Association.

(4) THE AMERICAN RAILWAY ENGINEERING ASSOCIATION.

This Association from the time of its organization in 1899 to the present time has taken an active interest in the matter of a proper rail section; in fact, the first outline for committee work had as one of its principal subjects "Standard Sections and Weights of Rail." A report was made by the Committee on Rail at the March, 1915, meeting, recommending for future use, the sections herein submitted.

These sections were prepared in accordance with the instructions of The American Railway Association, and in developing them, compromises were necessary, but the Committee believed that no vital point that should govern the design of rail sections was sacrificed in the effort to secure a single standard type instead of the type "A" and type "B" sections of The American Railway Association.

Suggestions were made that a common fishing space and common width of base be used for two or more weights of rail. To use a common fishing space for more than one weight of rail would result in sacrificing one of the most expensive parts of the track (the rail) in order to help out a much less expensive part (the joint), and this would be a violation of principles which should control the work of an engineer. The use of a common width of base for more than one weight of rail is less objectionable, for the only bad feature would be a slight reduction in the section's stability against overturning; therefore, the Committee deemed it wise to propose different fishing spaces and widths of base for each of the sections recommended.

The designs submitted have kept in view the feature of the rail as a girder with the highest ratio of section modulus to area of section. The radii of the fillets between the head and web, and web and base have been made as large as possible without interfering with the bearing between the joint bars on the head.

Studies for sections weighing 130 and 140 lbs. per yard, embodying the ideas of the Committee in regard to such sections were submitted.

No new designs for sections under 100 lbs. are proposed. The 90-lb. A.R.A. "A" section being recommended for the single type standard. The sections under 100 lbs., now in general use, do not vary sufficiently from those that might be submitted to make any marked difference so far as mill practice or wear in service are concerned. The distribution of the metal in sections of 80 lbs. and under is such that it cannot be varied from, except in minute details, which do not affect the life or safety of the rail in service. It is thought that the use of these sections will be limited and will decrease because of the increasing wheel loads, and that no new sections will be purchased, as the mills are equipped with rolls for the sections now commonly used.

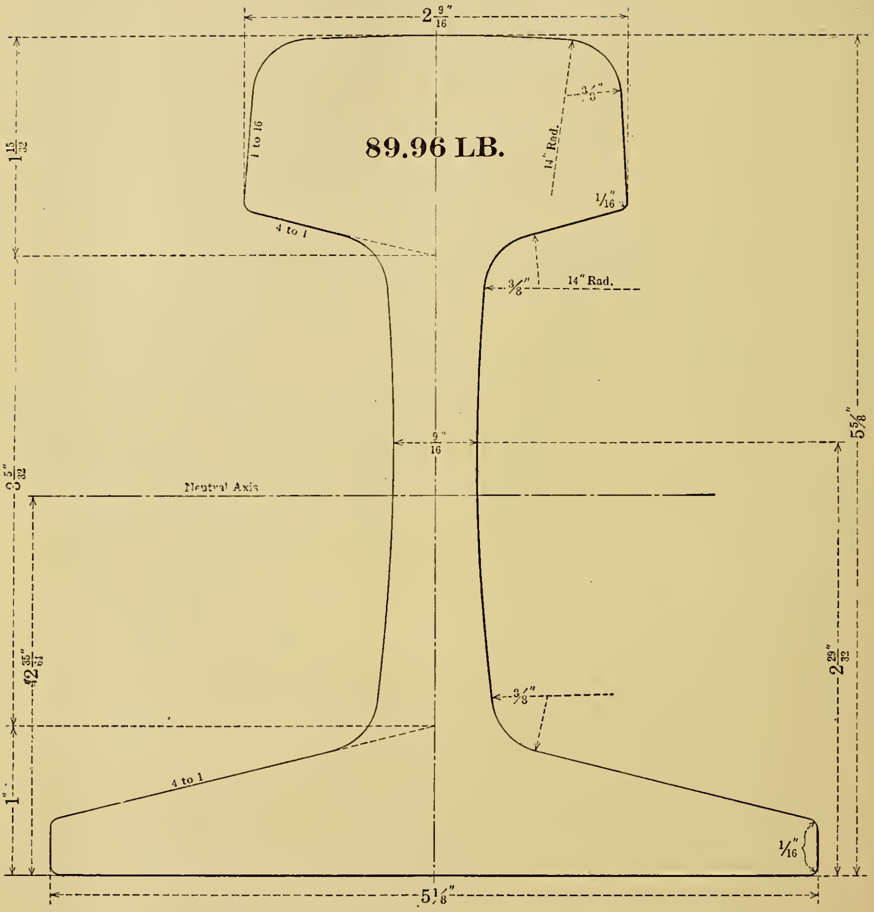
The American Railway Engineering Association in presenting these sections to the railroads earnestly requests that they be given careful consideration before the introduction of any new section of their own design. Several canvasses of the situation indicate a disposition on the part of most of the railroads to make no change in their standards, and with this there is no reason to find fault, but where it is found necessary to adopt a new pattern or a heavier weight of rail, the A.R.E.A. sections, if possible, should be made the standard. The impossibility of making a single standard section that will meet the individual taste of every engineer must be recognized, and it is apparent that any variation from these designs would be so slight that the substitution of another section would hardly be justified. It has been difficult to reconcile the views of those whose road conditions, in their judgment, require a deep-headed rail. Experience indicates, however, that where the section in use is found inadequate for the conditions of service, because of depth of head, it is desirable, and, further, economical to use a heavier weight section, and in cases where the 100-lb. section of the Association will not satisfy the conditions of service, the 110 or 120-lb. section should be used.

Some such course as recommended above must be taken if we are to avoid a repetition of the lamentable conditions prevailing at the time that the subject was taken up by the American Society of Civil Engineers and so admirably described by Messrs. Holley and Mattes in their papers read before the American Institute of Mining Engineers.

(For further information as to the work of this Association, see Annual Proceedings, Vol. II, page 189 [1901]; Vol. III, page 200 [1902]; Vol. IX, page 431 [1908]; Vol. X, Part 1, page 334 [1909], and Vol. XIII, page 43 et seq. [1913].)

[3] RAIL SECTIONS.

R. A.-A.—90-LB.



Area:				
Head	=3.20	sq.	in.	36.2%
Web	=2.12	"	"	24.0%
Base	=3.50	"	"	39.8%
Total	=8.82	"	"	100.0%

Moment of Inertia	38.7
Section Modulus, Head	12.56
" " Base	15.23
Ratio M.I. to Area	4.39
Ratio Sec. Mod. to Area	1.42

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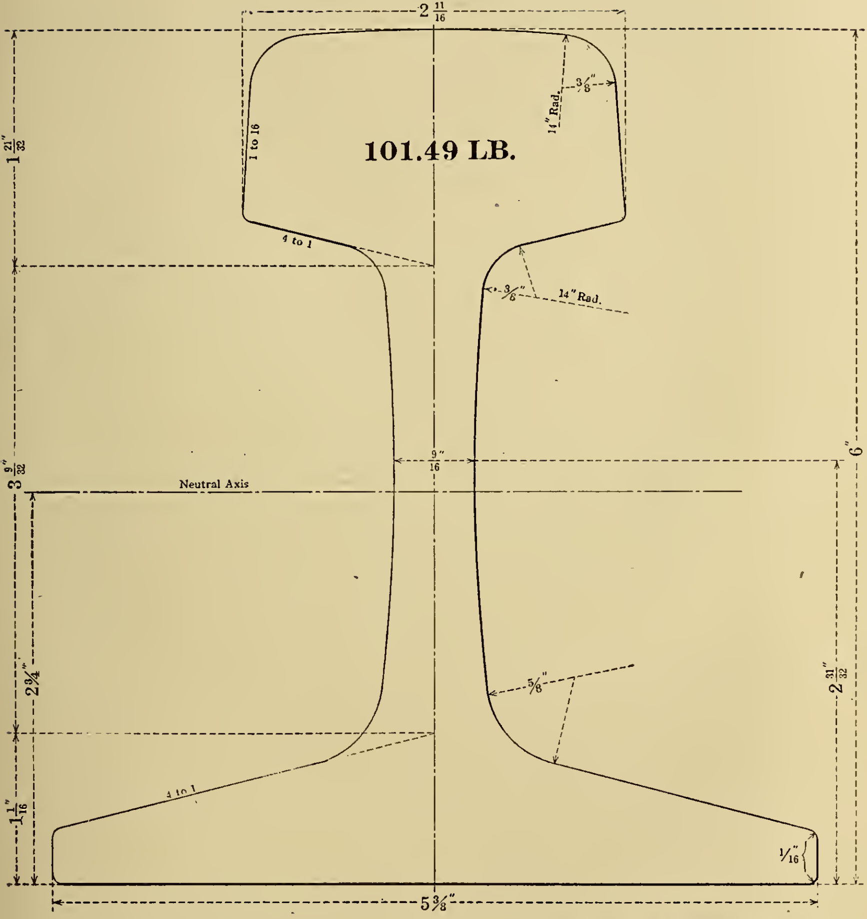
[3] Adopted, Vol. 16, 1915, pp. 397, 1117.

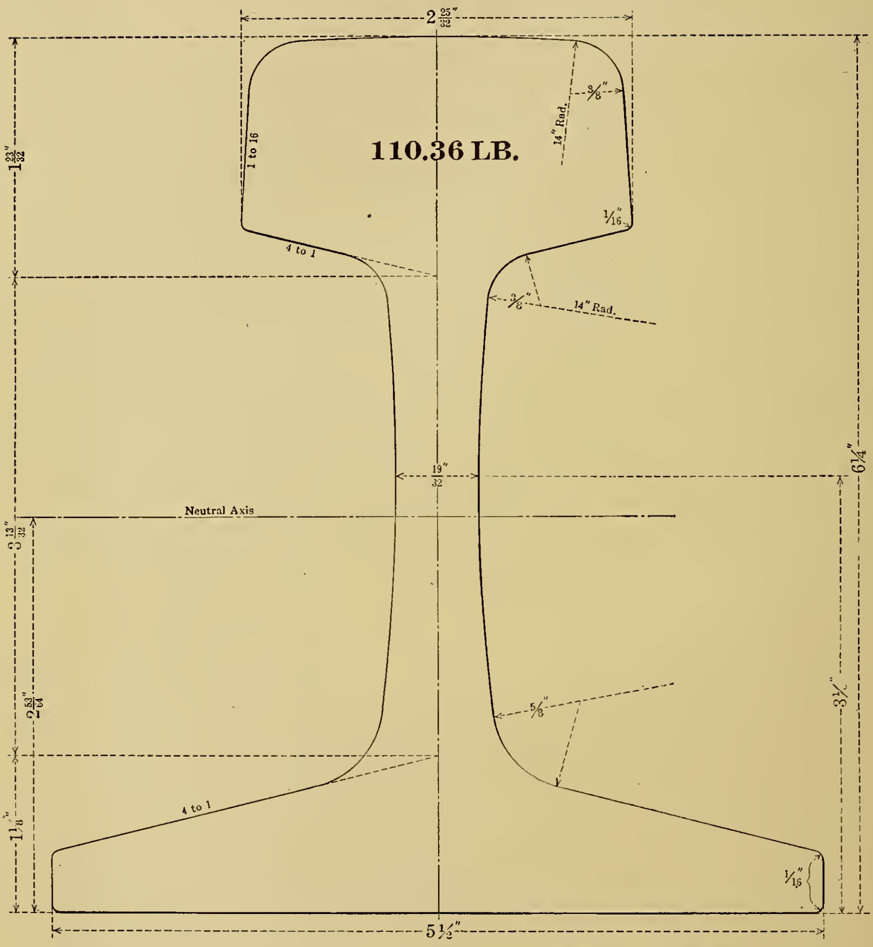
R. E.—100-LB.



Area: Head	=3.80	sq. in.	38.2%
Web	=2.25	" "	22.6%
Base	=3.90	" "	39.2%
Total	=9.95	" "	100.0%

Moment of Inertia	49.0
Section Modulus, Head	15.1
" " Base	17.8
Ratio M.I. to Area	4.92
Ratio Sec. Mod. to Area	1.52

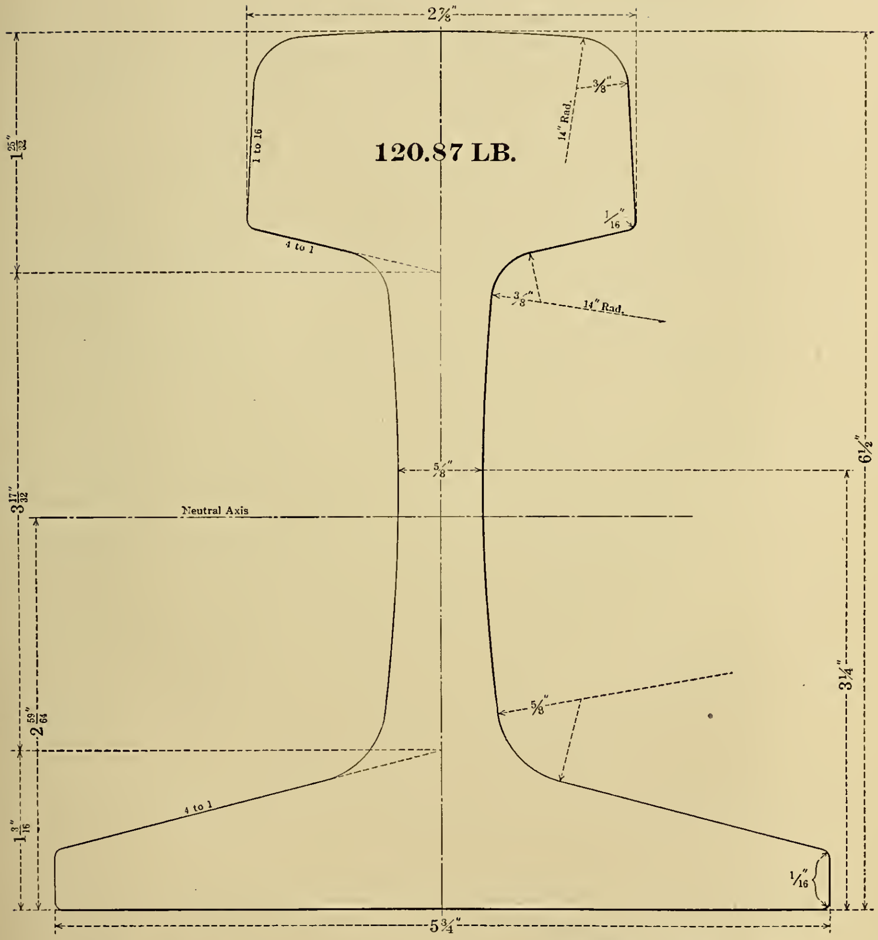
R. E.—110-LB.



Area:			
Head	=4.04	sq. in.	37.4%
Web	=2.49	" "	23.0%
Base	=4.29	" "	39.6%
Total	=10.82	" "	100.0%

Moment of Inertia	57.0
Section Modulus, Head	16.7
" " Base	20.1
Ratio M.I. to Area	5.27
Ratio Sec. Mod. to Area	1.55

R. E.—120-LB.

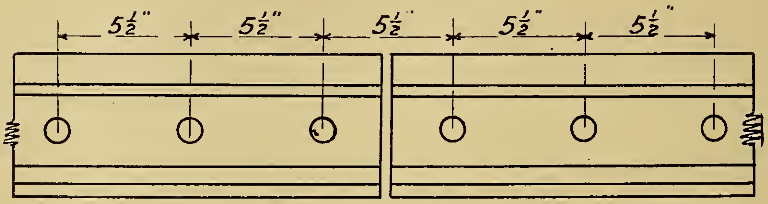


Area:				
Head	=4.40	sq.	in.	37.1%
Web	=2.69	"	"	22.7%
Base	=4.76	"	"	40.2%
Total	=11.85	"	"	100.0%

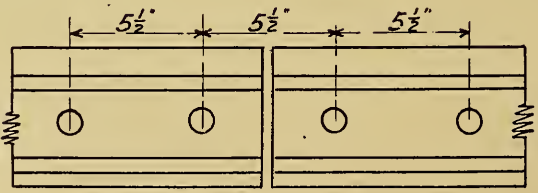
Moment of Inertia	67.6
Section Modulus, Head	18.9
" " Base	23.1
Ratio M.I. to Area	5.71
Ratio Sec. Mod. to Area	1.59

[3] STANDARD DRILLING FOR RAILS.

The standard drilling for rails should be as shown in the following diagrams:



RECOMMENDED 6-HOLE DRILLING.



RECOMMENDED 4-HOLE DRILLING.

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[3] Adopted, Vol. 15, 1914, pp. 157, 1110.

[4] SPECIFICATIONS FOR DROP TEST MACHINE.

A drop test machine conforming essentially to the manufacturers' plans and specifications and in general accord with the following requirements will give satisfactory results:

1. The machine shall be arranged to allow a 2000-lb. tup to fall freely at least 25 feet on the center of a rail resting on supports that can be adjusted to spans varying from 3 feet to 4 feet 6 inches.

2. The anvil shall be a solid casting, weighing, with the attachments that move with it, 20,000 lbs. It shall be free to move vertically independent of the lead columns. It shall be supported on 20 springs known as the standard "C" spring, without center coil, as employed by the Master Car Builders' Association (their Fig. 5614). This spring has a free length of eight and one-quarter (8¼) inches, an outside diameter of five and seven-sixteenths ($5\frac{7}{16}$) inches, and is made from a bar having a diameter of one and three-sixteenths ($1\frac{3}{16}$) inches. These springs shall be arranged in groups of five at each corner of the anvil. They shall be held in place by hubs raised on the top of the base plate, and by circular pockets on the underside of the anvil. The anvil shall be guided in its vertical movement by removable finished wearing strips. These wearing strips shall be suitably attached to the finished edges of the column base.

3. The base-plate shall be of cast-iron or cast steel eight (8) inches thick in the area covered by the anvil. It shall be firmly secured to the substructure by four bolts two (2) inches in diameter.

4. The substructure shall consist of a timber grillage resting on a masonry foundation. The grillage shall project nine (9) inches beyond the ends of the base plate, and clear the columns at the side. It shall consist of one course of twelve by twelve (12 by 12) inches sound oak or Southern yellow pine, preferably creosoted, laid close and well bolted together. The masonry, preferably concrete, shall be not less than five (5) feet deep below the grillage, suitably supported on the subsoil.

5. The pedestals for supporting the test rail shall be substantial castings. The surface of the anvil between these pedestals shall be formed to receive a wooden block to absorb shock under broken test pieces. The rail supports shall be removable pieces of steel, securely

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[4] Adopted, Vol. 10, Part 1, 1909, pp. 369-373, 375, 395, 396; Vol. 11, Part 1, 1910, pp. 240, 252, 562.

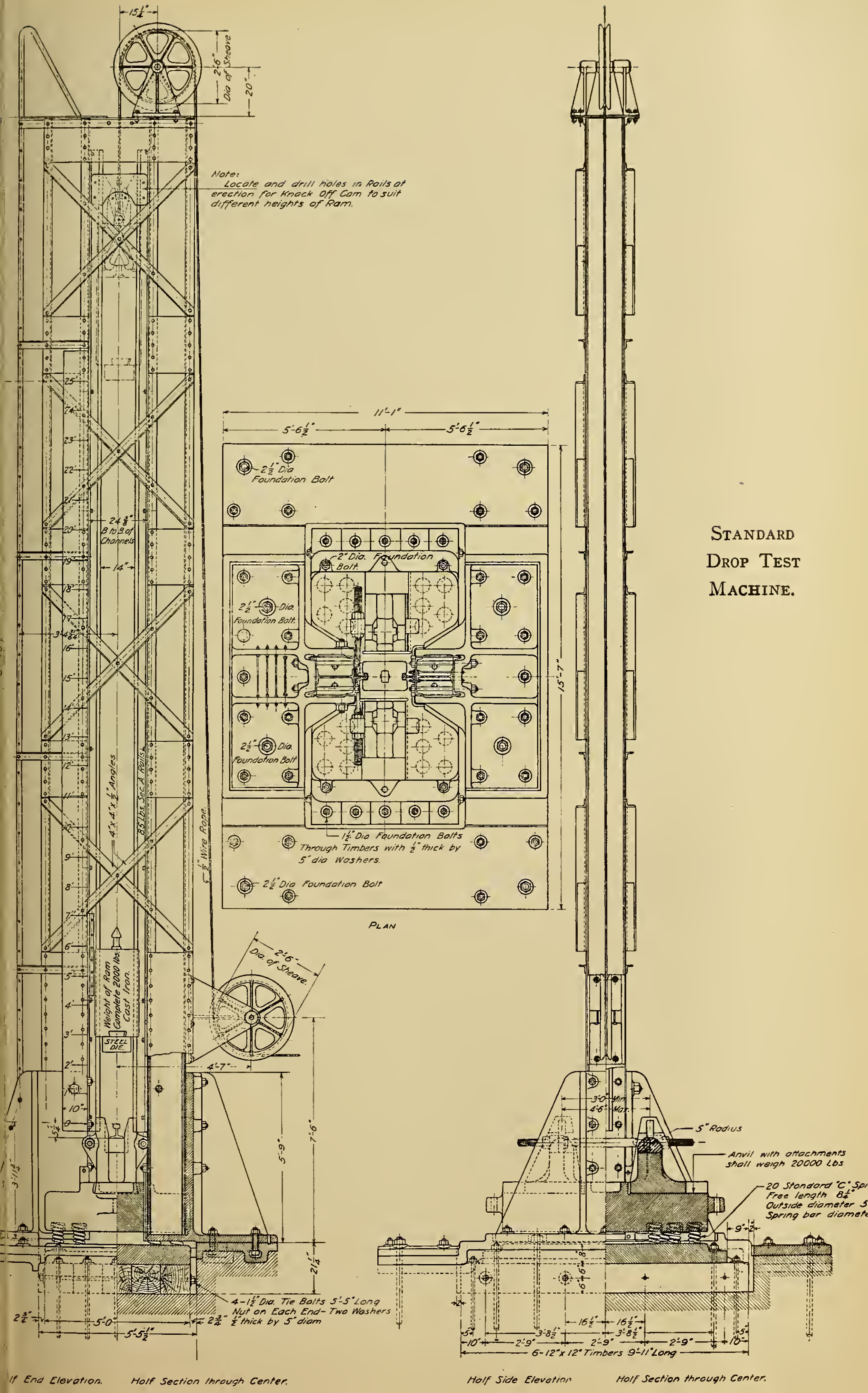
held in the pedestals, having an upper cylindrical bearing surface, with a radius of five (5) inches. The pedestals shall be adjustable to spans varying from three (3) feet minimum to four (4) feet six (6) inches maximum between centers. They shall be securely held together, and so fixed to the anvil as to insure that the center of the span shall always coincide with the center between leads.

6. The leads shall be firmly connected to the column base and well braced. They shall be long enough to provide the prescribed free fall of the tup. They shall be provided with a convenient ladder and a plainly marked gage, divided into one-foot intervals. The zero of this gage shall be five and one-quarter (5¼) inches above the top of the rail support. The specified height of drop shall be measured from this zero irrespective of the height of the rail being tested. One of the guides shall have a removable section six (6) feet long at the bottom, so that the tup or tripping block may be readily removed.

7. The tup shall weigh, with the accessories that drop with it, 2000 lbs. The striking die shall be of steel, having a cylindrical striking face, with a radius five (5) inches and a length of twelve (12) inches. The guide grooves shall have finished surfaces. The tripping head shall allow a grip of the tongs that will release at the exact height for which the tripping device is set, and that will be safe from accidental release while the test piece is being shifted.

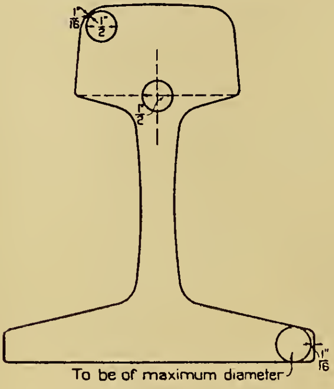
8. The tongs and tripping device shall be arranged to release the tup automatically only. No manual releasing will be allowed. The tripping device shall be easily adjusted at one-foot intervals.

STANDARD DROP TEST MACHINE.

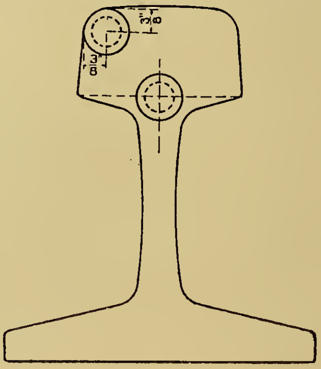


[5] STANDARD LOCATIONS OF BORINGS FOR CHEMICAL ANALYSES AND TENSILE TEST PIECES.

FOR CHEMICAL ANALYSES.

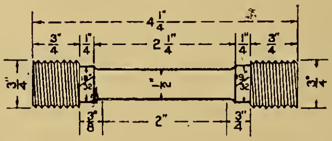


FOR TENSILE TEST PIECES.



NOTE

IF RAIL IS FLANGE WORN, THE BORINGS AND TEST PIECE FROM THE UPPER PART OF HEAD SHALL BE TAKEN FROM THE OPPOSITE CORNER.



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[5] Adopted, Vol. 12, 1916, Part 1, p. 469; Part 2, p. 14.

[6] SPECIFICATIONS FOR HIGH-CARBON STEEL JOINT BARS.

Basis of Purchase.

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the joint bars have been made in accordance with the terms of the specifications.

2. All tests and inspection shall be made at the place of manufacture prior to loading, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

Material.

3. Material for joint bars shall be steel, made by the open-hearth process.

Chemical Properties.

4. The chemical composition of each melt of steel from which joint bars are manufactured shall be within the following limits:

Phosphorus, per cent., maximum 0.04.

5. The manufacturer shall furnish the inspector a complete report of ladle analysis, showing carbon, manganese, phosphorus and sulphur content of each melt represented in the finished material. The purchaser may make a check analysis from the finished material; such analysis shall conform to the requirements of Section 4.

Physical Properties and Tests.

6. Joint bars shall conform to the following physical requirements:
   - (a) Tensile strength, lbs. per square inch, minimum, 85,000.
   - (b) Elongation, per cent. in 2 inches, minimum, 16.
   - (c) Cold bending without fracture on the outside of the bent portion through 90 degrees around an arc the diameter of which is three times the thickness of the test piece.

7. All test pieces shall be cut from finished bars.
   - (a) Standard ½ by 2-inch specimens, as adopted by the American Society for Testing Materials, shall be used for tension test.
   - (b) The bend test specimen shall be ½ inch square in section, or a rectangular bar ½ inch thick, with two parallel faces as rolled.

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[6] Adopted, Vol. 16, 1915, pp. 403, 1119.

General Requirements.

8. The different sections of joint bars shall be rolled to dimensions specified in drawing furnished by the purchaser. No variation will be allowed in the dimensions affecting the fit and the fishing spaces of the rail. The maximum camber on either plant shall not exceed 1/32 inch in 24 inches.

9. The joint bars shall be sheared to the length prescribed by the purchaser and shall not vary therefrom by more than ⅛ inch.

10. (a) All joint bars shall be punched, slotted and shaped at a temperature of not less than 800 degrees Centigrade (1470 degrees Fahrenheit.).

(b) All bolt holes shall be punched in one operation, without bulging or distorting the section, and the bars shall be slotted for spikes when required, in accordance with the drawings, the slotting being done in one operation; a variation of 1/32 inch in the size and location of the holes will be allowed.

11. All joint bars must be finished smooth and true, without swelling over or under the bolt holes, and be free from flaws, seams, checks or fins, and the fishing angles must be fully maintained.

12. The manufacturer's identification symbol, kind of material, month and year rolled and number of design, shall be rolled in raised letters and figures on each bar. The number of the melt shall be plainly stenciled on each lot of joint bars.

Inspection.

13. The joint bars from each melt shall be piled separately until tested and inspected by the purchaser's inspector. One joint bar for tension test shall be slected by the inspector for each melt represented in finished bars, or by agreement specimen for tension test may be cut from the bar as rolled. One joint bar for bend test shall be selected by the inspector for each lot of 1000 bars or less presented.

[7] SPECIFICATIONS FOR HEAT-TREATED, OIL-QUENCHED, STEEL JOINT BARS.

Basis of Purchase.

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the joint bars have been made and loaded in accordance with the terms of the specifications.

2. All tests and inspection shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

Material.

3. Material for joint bars shall be steel, made by the Open-Hearth process.

Chemical Properties.

4. The chemical composition of each melt of steel from which joint bars are manufactured shall be within the following limits:

Phosphorus, per cent., maximum, 0.04.

5. The manufacturer shall furnish the inspector a complete report of ladle analysis, showing carbon, manganese, phosphorus and sulphur content of each melt represented in the finished material. The purchaser may make check analysis from the finished material; such analysis shall conform to the requirements in Section 4.

Physical Properties and Tests.

6. Joint bars shall conform to the following physical requirements:

(a) Tensile strength, lbs. per square inch, minimum, 100,000.

(b) Yield point, lbs. per square inch, minimum, 70,000.

(c) Elongation, per cent. in 2 inches, not less than $\frac{1{,}500{,}000}{\text{Ten. str.}}$ minimum, 12.

(d) Cold bending without fracture on the outside of the bent portion through 90 degrees around an arc, the diameter of which is one and one-half times the thickness of test piece.

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[7] Adopted, Vol. 16, 1915, pp. 404, 1119.

7. All test pieces shall be cut from finished bars.

(a) Standard ½ by 2-inch specimens, as adopted by the American Society for Testing Materials, shall be used for tension test.

(b) The bend test specimens shall be ½ inch square in section, or a rectangular bar ½ inch thick with two parallel faces as rolled.

Heat Treatment.

8. Joint bars shall be heated and quenched in an oil bath from a temperature of about 810 degrees Centigrade (1490 degress Fahrenheit), and shall be kept in the oil bath until cold enough to be handled.

General Requirements.

9. Joint bars shall be rolled to dimensions specified in drawing furnished by the purchaser. No variation will be allowed in the dimensions affecting the fit and the fishing spaces of the rail. The maximum camber in either plane shall not exceed $\frac{1}{32}$ inch in 24 inches.

10. Joint bars shall be sheared to the length prescribed by the purchaser and shall not vary therefrom by more than ⅛ inch.

11. (a) All joint bars shall be punched, slotted and shaped at a temperature of not less than 800 degrees Centigrade (1470 degrees Fahrenheit).

(b) All bolt holes shall be punched in one operation without bulging or distorting the section, and the bars shall be slotted, when required, for spikes in accordance with the purchaser's drawing, the slotting being done in one operation. A variation of $\frac{1}{32}$ inch in size and location of the holes will be allowed.

12. All types of joint bars must be finished smooth and true without swelling over or under the bolt holes, and be free from flaws, seams, checks or fins. The fishing angles must be fully maintained.

13. The manufacturer's identification symbol, kind of material, month and year rolled, number of design, and the letters "HT" to signify heat-treated, shall be rolled in raised letters and figures on each bar. The number of the melt shall be plainly stenciled on each lot of joint bars.

Inspection.

14. The joint bars from each melt or heat treatment lot shall be piled separately until tested and inspected by the inspector. One joint bar for tension test shall be selected by the inspector for each melt or

heat treatment lot represented in finished bars. One joint bar for bend test shall be selected by the inspector for each lot of 1000 bars or less presented, or from each heat treatment lot.

[8] RAIL RECORD FORMS.

(1) The following forms are considered essential and are recommended for keeping rail statistics and records:

Group I—Reports of Rail Inspection and Shipment at the Mill:

Form M. W. 401, 401-A, Report of Mill Inspection.

Form M. W. 402, Certificate of Inspection.

Form M. W. 403, Report of Shipment.

Form M. W. 418, Tabulation of Results of Mill Inspection of Rails Rolled.

Group II—Reports from Division Officers:

Form M. W. 404, Report of Rail Failures in Main Tracks.

Form M. W. 405, Superintendent's Monthly Report of Rail Failures in Main Tracks.

Form M. W. 406, Annual Statement of Steel Rails Existing in Main Tracks.

Group III—Laboratory Examination of Special Rails:

Form M. W. 407, Laboratory Rail Report.

Group IV—Compilation of Results for Study:

Form M. W. 408, Summary of Steel Rail Failures for One Year.

Form M. W. 409, Summary of Steel Rail Failures for a Period of Years.

Form M. W. 410, Comparative Number of Failures of Steel Rails of Different Section or Pattern, Rolled by Different Steel Companies.

Form M. W. 412, Cover for Forms M. W. 408, 409, 410.

Group V—Progressive Wear of Special Rails under Observation:

Form M. W. 413, Location Diagram. (Scale of 1 inch = one mile.)

Form M. W. 414, Location Diagram. (Scale of 2 inches = one mile.)

Form M. W. 415, Diagram showing Lines of Wear.

Form M. W. 416, Record of Comparative Wear of Special Rail.

Form M. W. 417, Cover for Forms M. W. 413, 414, 415, 416.

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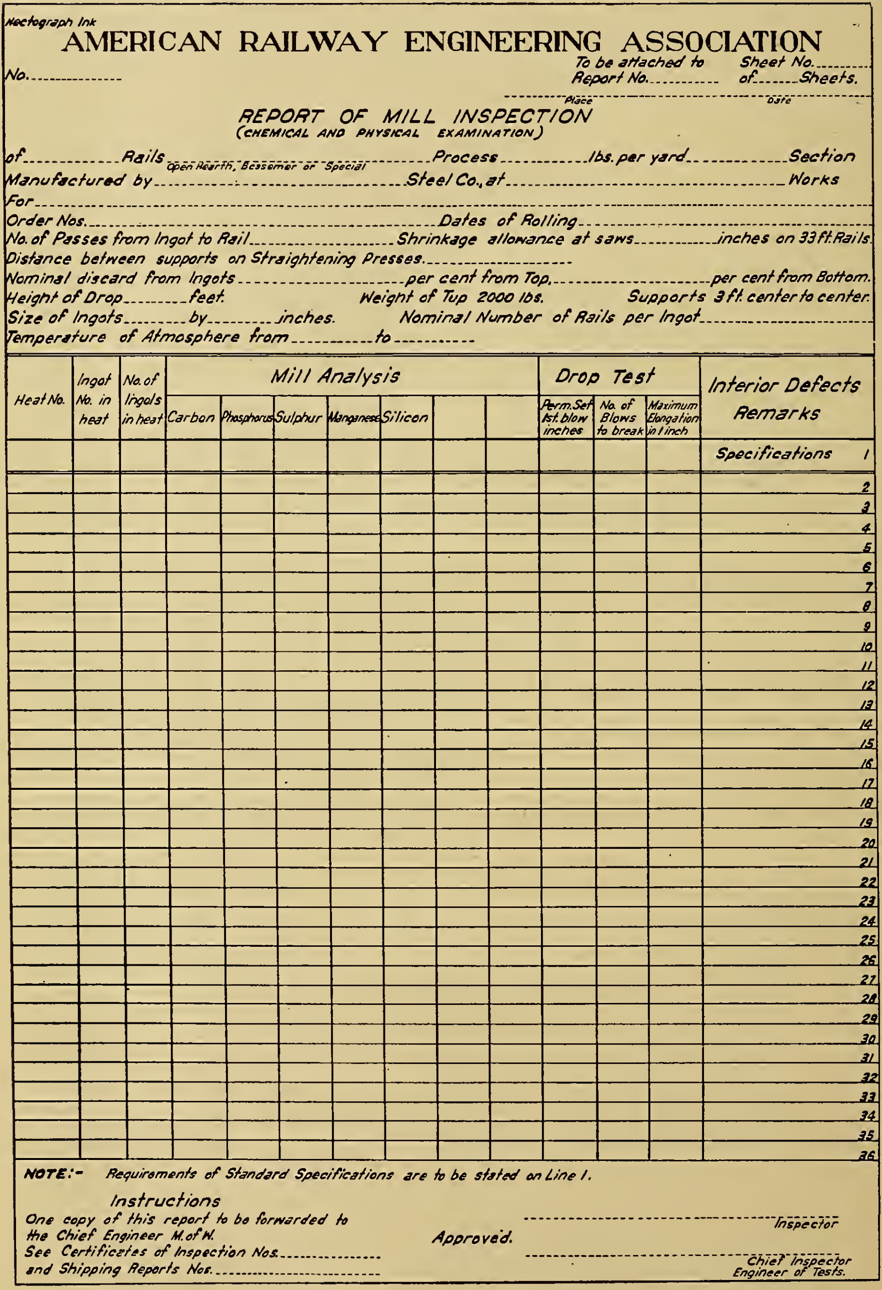
[8] Adopted, Vol. 10, 1909, pp. 339-363, 375, 393-395; Vol. 11, Part 2, 1910, pp. 241-251, 576-579; Vol. 12, 1912, Part 1, p. 467, Part 2, p. 17.

[9] RAIL RECORD FORMS.

Group I.

Form M. W. 401.



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AMERICAN RAILWAY ENGINEERING ASSOCIATION

No.______________ To be attached to Report No.__________ Sheet No.________ of______Sheets.

________________________ Place ________________ Date

REPORT OF MILL INSPECTION
(CHEMICAL AND PHYSICAL EXAMINATION)

of___________Rails __Open Hearth, Bessemer or Special__ _______Process__________lbs. per yard___________Section
Manufactured by______________________________Steel Co., at______________________________Works
For____
Order Nos.________________________________Dates of Rolling________________________________
No. of Passes from Ingot to Rail__________________Shrinkage allowance at saws___________inches on 33 ft. Rails.
Distance between supports on Straightening Presses__________________
Nominal discard from Ingots____________________per cent from Top,___________________per cent from Bottom.
Height of Drop________feet. Weight of Tup 2000 lbs. Supports 3 ft. center to center.
Size of Ingots________by________inches. Nominal Number of Rails per Ingot____________________
Temperature of Atmosphere from__________to__________

Heat No.	Ingot No. in heat	No. of Ingots in heat	Mill Analysis							Drop Test			Interior Defects Remarks
			Carbon	Phosphorus	Sulphur	Manganese	Silicon			Perm. Set 1st blow inches	No. of Blows to break	Maximum Elongation in 1 inch	
													Specifications 1
													2
													3
													4
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NOTE:- Requirements of Standard Specifications are to be stated on Line 1.

Instructions

One copy of this report to be forwarded to the Chief Engineer M. of W.
See Certificates of Inspection Nos.______________
and Shipping Reports Nos.______________________

Approved. ______________________________Inspector

______________________________Chief Inspector
Engineer of Tests.

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[9] Adopted, Vol. 10, 1909, pp. 339-363, 375, 393-395; Vol. 11, Part 2, 1910, pp. 241-251, 576-579; Vol. 12, Part 1, 1912, pp. 467, 468; Part 2, pp. 17, 18; Vol. 14, 1913, pp. 188-192, 1104, 1105.

Form M. W. 401-A.

Hectograph Ink

AMERICAN RAILWAY ENGINEERING ASSOCIATION

No................

To be attached to Report No.............. Sheet No........ of.......Sheets

.......................Place ....Date

REPORT OF MILL INSPECTION

(CHEMICAL AND PHYSICAL EXAMINATION)

Heat No.	Ingot No. in heat	No. of Ingots in heat	Mill Analysis							Drop Test			Interior Defects Remarks
			Carbon	Phosphorus	Sulphur	Manganese	Silicon			Perm. Set 1st blow inches	No. of blows to break	Maximum Elongation in 1 inch	
													Specifications 1
													2
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NOTE:- Requirements of Standard Specifications are to be stated on Line 1.

Instructions

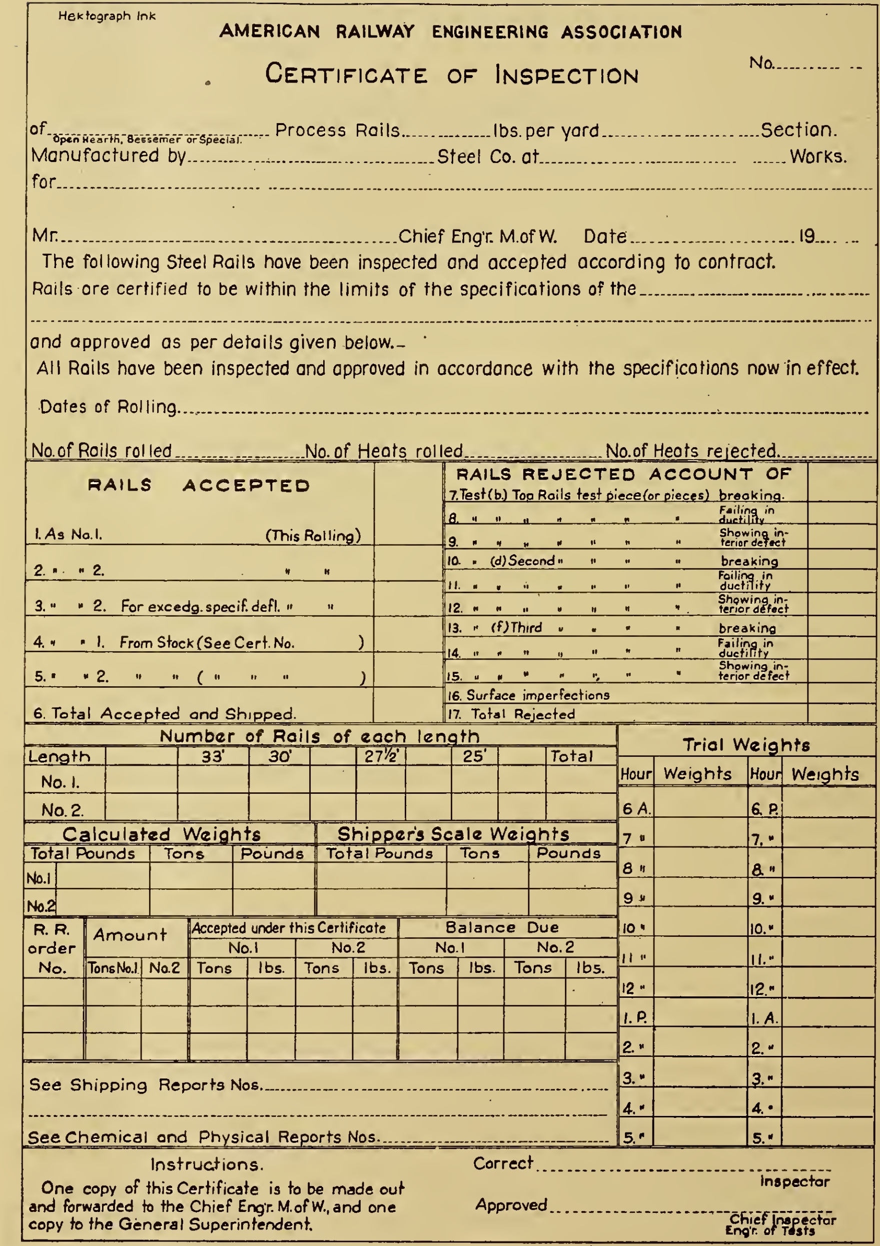
One copy of this report to be forwarded to
the Chief Engineer M. of W.
See Certificates of Inspection Nos.................
and Shipping Reports Nos..................

.... Inspector

Approved.

.... Chief Inspector
Engineer of Tests.

Form M. W. 402.



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AMERICAN RAILWAY ENGINEERING ASSOCIATION

CERTIFICATE OF INSPECTION

No..........

of .... Process Rails.............lbs. per yard.......................Section.
Open Hearth, Bessemer or Special.

Manufactured by.................................Steel Co. at.............................Works.

for...

Mr...Chief Eng'r. M. of W. Date....................19....

The following Steel Rails have been inspected and accepted according to contract.

Rails are certified to be within the limits of the specifications of the..........................

....

and approved as per details given below.–

All Rails have been inspected and approved in accordance with the specifications now in effect.

Dates of Rolling...

No. of Rails rolled..................No. of Heats rolled..................No. of Heats rejected..............

RAILS ACCEPTED	
1. As No. 1. (This Rolling)	
2. " " 2. " "	
3. " " 2. For excedg. specif. defl. " "	
4. " " 1. From Stock (See Cert. No.)	
5. " " 2. " " (" " ")	
6. Total Accepted and Shipped.	

RAILS REJECTED ACCOUNT OF		
7. Test (b.) Top Rails test piece (or pieces)	breaking.	
8. " " " " " " "	Failing in ductility	
9. " " " " " " "	Showing interior defect	
10. " (d) Second " " " "	breaking	
11. " " " " " " "	Failing in ductility	
12. " " " " " " "	Showing interior defect	
13. " (f) Third " " " "	breaking	
14. " " " " " " "	Failing in ductility	
15. " " " " " " "	Showing interior defect	
16. Surface imperfections		
17. Total Rejected		

Number of Rails of each length									
Length		33'	30'		27½'		25'		Total
No. 1.									
No. 2.									

Calculated Weights				Shipper's Scale Weights		
Total Pounds		Tons	Pounds	Total Pounds	Tons	Pounds
No. 1						
No. 2						

R. R. order No.	Amount		Accepted under this Certificate				Balance Due			
			No. 1		No. 2		No. 1		No. 2	
	Tons No. 1	No. 2	Tons	lbs.	Tons	lbs.	Tons	lbs.	Tons	lbs.

Trial Weights			
Hour	Weights	Hour	Weights
6 A.		6. P.	
7 "		7. "	
8 "		8. "	
9 "		9. "	
10 "		10. "	
11 "		11. "	
12 "		12. "	
1. P.		1. A.	
2. "		2. "	
3. "		3. "	
4. "		4. "	
5. "		5. "	

See Shipping Reports Nos...

....

See Chemical and Physical Reports Nos.......................................

Instructions.

One copy of this Certificate is to be made out and forwarded to the Chief Eng'r. M. of W., and one copy to the General Superintendent.

Correct.......................................
Inspector

Approved......................................
Chief Inspector
Eng'r. of Tests

Form M. W. 403.

Copy Ink

A. B. & C. R. R. Co.

No._____

REPORT OF SHIPMENT.

of __________________ Process Rails __________ lbs. per yd ____________ Section
(Open Hearth, Bessemer or Special.)
Manufactured by ______________________ Steel Co. at __________________ Works.
for ____
Consigned to ____
Order No. ________________ Date of Report _____________________ 19__
Quality No. _______________ Sheet No _____ of ____ Sheets.

	Loaded on Cars.		Number of Rails of each Length.									Shipper's Weights Pounds
	Initial	No.		33	32	31	30			25	Total Rails	
1												
2												
3												
4												
5												
6												
7												
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14	For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures.											
8 15	9	9	5	5	5	5	5	5	5	5	6	8
16				Size of sheet required 8x10½ inches								
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32												
		Totals										
	Total Weight Expressed in Gross Tons and Decimals.											

Total Tons of Order _______ Tons previously shipped _____ Balance due __________

INSTRUCTIONS

One copy of this report is to be sent to the Chief Engineer M of W., and two copies to the General Superintendent, one of which is for the Division Superintendent

Correct __________________________
Inspector

Approved _________________________
Chief Inspector.
Engineer of Tests.

Group II.

Form M. W. 404.

A. B. & C. R. R. Co.

No..................

......................Division.......................Branch.

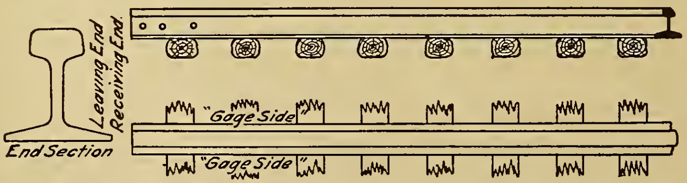
REPORT OF RAIL FAILURES IN MAIN TRACKS

Section No.......... Date of Report..........................191...

1 Weight per yard, New..............lbs
Re-rolled ....lbs.
2 Rail Section?........................
3 Brand on Rail? ("D" on back)........
4 Kind of Steel? ("E" on back)........
5 Heat No. on Rail? ("F"on back)......
6 Rail No. or Letter? ("F" on back)....
7 Original Length of Rail?.............
8 Month and Year Rail was Laid........
9 Location ....Feet ....of Mile Post ....
10 Which Track?........................
Which Rail? ....
11 On Curve or Straight Line?...........
11½ No. of Curve?.......................
12 Degree of Curve?...................
13 High or Low Rail, if on Curve?.......
14 Superelevation of Curve at "Break"?.. ....
15 Was Rail "Broken"?..................
or "Defective"? ....
or Damaged? ....
(See "Description of Failures" on back)

16 Was Rail much or little worn?.......
17 By whom discovered................
18 Date and Time found?...............
19 Was Rail removed?.................
Date removed? ....
20 Exact gage of Track at "Break"?.....
21 Was "Break" over or between Ties?..
22 Was "Break" square or angular?.....
23 Distance between edges of Ties at "Break?" ....
24 Condition of Ties each side of "Break?" ....
25 Kind of Ties?.........................
26 Were Tie Plates used?..............
Kind? ....
27 Condition of Line and Surface?......
28 Kind of Ballast?....................
29 Was Track properly ballasted?.......
30 Kind of material in roadbed under ballast? ....
31 Was Track well drained?............
32 Was Roadbed frozen?...............

33 Condition of weather? (Wet, dry, warm or cold, freezing or thawing)............
34 If "Broken," state cause of break, and describe any flaws found at point of break ....
35 If "Break" was at joint, state kind, number of holes, and whether it was full bolted or insulated...
36 Were any bolts at joint loose?.....................If so, how many?............
37 Was accident or detention to trains caused by "Break"?........................
If so, state circumstances...
38 If "Defective," describe kind and location of flaws or defects, and if possible, what caused them. (See "Description of Failures" on back)..................
....
....
39 Draw on Diagram lines of "Break," or partial fracture, such as long pieces from side of head and half-moon pieces from base, showing dimensions. Hollows in head should be shown on "End Section." Defects may also be indicated on Diagram. Mark distance from end to "Break." *If "Break" is nearest "Receiving End," draw pen through words "Leaving End;" if nearest "Leaving End," draw pen through words "Receiving End." (*Refers to track upon which the current of traffic is in one direction.) Indicate "Gage Side" on "Diagram" below, by drawing pen through words "Gage Side" on opposite side.



40 If "Damaged," describe nature and cause if known. (See "Description of Failures" on back)...

Correct: Approved:

............................Foreman. ....Supervisor.

Instructions and Description of Failures on Back.

Back of Form M. W. 404.

INSTRUCTIONS

A. The Foreman will send this Report to the Supervisor the same day the break is discovered, and in the case of a damaged or defective rail, the day it is taken out of the track.

B. The Supervisor will forward this Report direct to the Division Engineer.

C. The Division Engineer will have copies of this Report made immediately upon receipt and send a copy to the Chief Engineer M. of W.

D. The answer to 3 is in raised characters on the web of the rail.

E. The answer to 4 is "Bessemer" (B); "Open-Hearth" (O.H.); "Nickel" (N.); "Ferro-titanium (F.T.); "Chrome Nickel" (C.N.); or other method of manufacture or alloy.

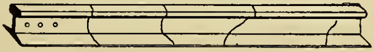
F. The answers to 5 and 6 are stamped into the metal on side of web—figures for 5 and a letter for 6.

G. Mile Post No. from {South East} end of Division to be used.

DESCRIPTION OF RAIL FAILURES

When describing Failures of Rails, the following terms should be used.

1. **Broken Rail.** This term is to be confined to a rail which is broken through, separating it into two or more parts. A crack which might result in a complete break will come under this head.

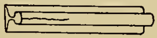


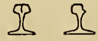
DEFECTIVE.

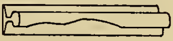
2. **Flow of Metal.** This term means a "Rolling Out" of the metal on top of the head towards its sides without there being any indication of a breaking down of the head structure, that is, the under side of the head is not distorted.

3. **Crushed Head.** This term is used to indicate a "Flattening" of the head, and is usually accompanied by a crushing down of the head as shown in sketch.

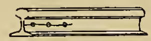
4. **Split Head.** This term includes rails split through or near the center line of the head, or rails with pieces split off the side of the head. When this term is used it should be further defined by stating whether it is or is not accompanied by a seam or hollow head.



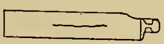


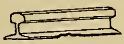


5. **Split Web.** This term is a longitudinal split along the axis of the web, generally starting from the end of rail through the bolt holes.



6. **Broken Base.** This term covers all breaks in base of rail and should be described and illustrated on sketches on front page.





7. **Damaged.** Under this head will be included all rails broken or injured by wrecks, broken wheels or similar causes.

Form M. W. 405.

A. B. & C. R. R. Co.

Sheet No......of......Sheets.

________________Division.

Superintendent's Monthly Report of **Rail Failures** in Main Track for the Month of________________19____

Report Number	Description of Rail									Location of Rail					Date Laid		Day of Month Found	Time in Service		Nature of Failure							In Splice	Out of Splice	Line No.
	Weight per Yard	Type of Section	Marks on Rail						Lengths	Mile Post		Which Track	Curve or Tangent	Degree of Curve	Mo.	Year		Year	Mos.	Damaged	Broken	Flow of Metal	Crushed Head	Split Head	Split Web	Broken Base			
			Manufacturer	Rolled		Kind of Steel	Heat No.	Rail Letter		No.	Feet																		
				Mo.	Year																								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
																													1
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																													17
																													18
																													19
																													20
																Total Failures													

Grand Total of Failures for Month

Use following Marks for making entries in Columns:
In Column 4 use Car. for Carnegie. Ill. S. W. for Illinois, South Works.
Ill. G. for Illinois, Gary. Cam. for Cambria.. Mar. for Maryland.
In Column 13 use E. B. P. for East Bound Passenger, etc.
" " 14 " T. for Tangent. I. C. for inner rail on Curve. O. C. for outer rail on Curve.
" " 21-22-23-24-25-26-27 use Fig. 1 to designate proper column.
Entries in Columns 21 to 27 should be repeated in Columns 28 or 29.

Instructions on back.

Correct.

.... Division Engineer

Approved.

.... Superintendent.

Back of Form M. W. 405.

INSTRUCTIONS

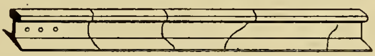
A. The Division Engineer will make out two copies of this report at the end of the month from the Section Foremen's Reports, and send one copy to the Chief Engineer M. of W. and one to the General Superintendent.

B. Mile Post No. from { South / East } end of Division to be used.

DESCRIPTION OF RAIL FAILURES

When describing Failures of Rails, the following terms should be used:

1. **Broken Rail.** This term is to be confined to a rail which is broken through, separating it into two or more parts. A crack which might result in a complete break will come under this head.

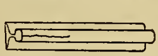


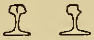
DEFECTIVE.

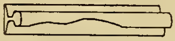
2. **Flow of Metal.** This term means a "Rolling Out" of the metal on top of the head towards its sides without there being any indication of a breaking down of the head structure, that is, the under side of the head is not distorted.

3. **Crushed Head.** This term is used to indicate a "Flattening" of the head, and is usually accompanied by a crushing down of the head as shown in sketch.

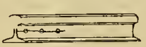
4. **Split Head.** This term includes rails split through or near the center line of the head, or rails with pieces split off the side of the head. When this term is used it should be further defined by stating whether it is or is not accompanied by a seam or hollow head.



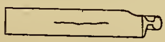


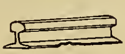


5. **Split Web.** This term is a longitudinal split along the axis of the web, generally starting from the end of rail through the bolt holes.



6. **Broken Base.** This term covers all breaks in base of rail and should be described and illustrated on sketches on front page.





7. **Damaged.** Under this head will be included all rails broken or injured by wrecks, broken wheels or similar causes.

Form M. W. 406.

A. B. & C. R. R. Co.

________________________________Division.

Statement of Steel Rails existing in Main Tracks of________________________________Division.

________________Main Track. December 31, 19___

Location.				Year Laid.	Brand.	Weight per Yard.	Type of Section.	Length of Feet in Track			
From		To						Laid Previous to 19	New Steel Laid 19	Steel Laid 19	Remarks.
M.P.	+ft.	M.P.	+ft.								
								1	2	3	4
	For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures.										
4	5	4	5	3	12	4	5	8	7	7	16
					Size of sheet required 8 inches wide.						

No. ft. 60 lb. Rail No. Tons
" " 70 " " " "
" " 85 " " " "
" " 100 " " " "

Column 3 to be used for any special rail, such as Re-rolled or Sawed and Re-drilled.

Correct:

To be made out and forwarded by the Engineer M. of W. to the Chief Engineer M. of W., as soon after the close of the year as possible.

Engineer M. of W.

Group III.

Form M. W. 407.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

No. ....

LABORATORY RAIL REPORT

................Date................19......

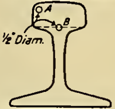
The following is report on rail referred to in ....

and which FAILED at ....Place of Failure.......... on ....Date of Failure..........

Rail made by ....Manufacturers Name.......... ....Date.......... ....Heat.......... ....Ingot Location..........

CHEMICAL ANALYSIS

Location	C.	P.	S.	Mn.	Si.		
A.							
B.							



DROP TEST

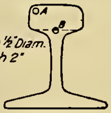
2000 lb. Tup. Supports 3' C. to C.

Position Head up or down	Height of Drop	Temperature of Atmosphere	Perm. set 1st. Blow	No. Blows to break	Max. Elong. in 1 inch	Max. Elong. in 2 Cons Ins.	Interior Defects and Remarks
Up							
Down	1' & Up						

TENSILE TESTS

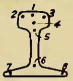
Location of Sample	Yield Point lbs. per sq. inch	Tensile Strength lbs. per sq. inch	Elongation per cent in 2 ins.	Reduction of Area. per cent	Fracture
A.					
B.					

Test Pieces ½" Diam.
Gauge Length 2"



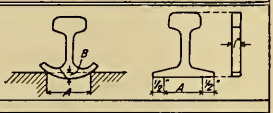
HARDNESS TESTS

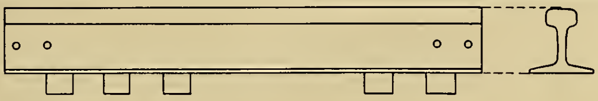
Location	1.	2.	3.	4.	5.	6.	7.	8.	Average
Brinell									
Scleroscope									



TRANSVERSE TEST OF BASE

Location	Breaking Load	Distance of Break from Ctr.	Max. Elong. in 1 inch	Per. Set 'B' measured on Mid. Ord.	Distance "A"
E. or N. of Fracture					
W. or S. of Fracture					





Show location and character of original fracture.

Remarks

....

....

....

....

....

....

Signature

Back of Form M. W. 407.

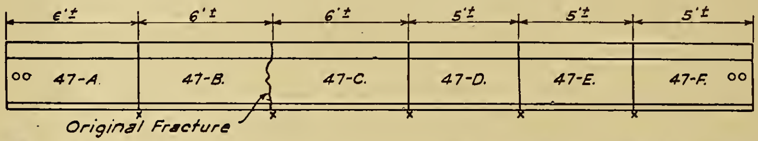
No.............. M.W. 407

AMERICAN RAILWAY ENGINEERING ASSOCIATION

GENERAL INSTRUCTIONS FOR SAMPLING AND TESTING RAILS FOR LABORATORY INVESTIGATION.

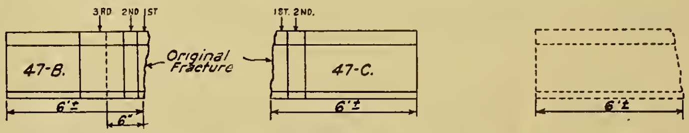
Send in to Railroad Test Department, at least two six foot sections, if possible, each to have original fracture intact. Preferably the whole rail is desired to be cut into pieces about six feet long.

Paint identification number and letters on all pieces, about as follows



Rail may be nicked at points shown by "X" and broken in manner usually employed by section gangs

Before Drop Testing, cut pieces containing original fracture as follows



Dotted Sections to govern when fracture is near the end.

1ST. CUT ON B. AND C. *Cut off original fracture, no further back than required to give full section in cut.*	*To be tagged with identification number and history, photographed and preserved.*
2ND. CUT ON B. AND C. *Sections exactly 1" long, one to be highly polished on side nearest original fracture. Take drillings with ½" drill from end of either B. or C. nearest original fracture. If more drillings are needed, take from corresponding part of 3rd. cut*	*Scleroscope and Brinnell Tests on one piece, transverse test on both.* *Compression test on one in order named for chemical analysis.*
3RD. CUT (Either B. or C., take nearest to original fracture) One Section 4¾" long.	*For tensile tests.*

All sections and test specimens to be stamped with identification numbers in shop.

Drop tests to be made as follows :- First test at specified height with base down, second test at one foot increments, starting at one foot with head down. Additional drop tests to be made if desired.

FORM M. W. 408.

SUMMARY OF STEEL RAIL
FAILURES FOR ONE YEAR.

Form M. W. 406

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Rail Failures for the Year Ending October 31, 191__

________________________________ Railroad

Kind of Steel	Mill	Year Rolled	Pounds Per Yard	Section	Railroad	Tons New Rail Laid	Equivalent Track Miles	Specified Carbon		Period	Number of Failures																									Failures per 100 Track Miles of New Rail Laid
											Head					Web					Base					Broken					Total					
								Min.	Max.		A	B	L	U	Total	A	B	L	U	Total	A	B	L	U	Total	A	B	L	U	Total	A	B	L	U	Total	
										This Year																										
										Total to Date																										
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INSTRUCTIONS FOR FILLING IN THIS FORM

1. Statistics are desired for rails weighing 70 lbs. per yard and over. Omit rail rolled previous to 1908. Omit information for lots of less than 1,000 tons.

2. Fill in the information concerning rail lots in which there were no failures, as well as for rail lots in which there were failures.

3. Rails broken or injured by wrecks, broken wheels or similar causes are not to be included in this report.

4. Express the tonnage of rails in whole numbers. Express the mileage in whole numbers and hundredths. Express the failures per 100 track miles in whole numbers and tenths.

5. Under "Kind of Steel" show whether the rails were bessemer, open-hearth or special steel.

6. Under "Number of Failures" the letter "A" denotes the top rail of the ingot; "B" denotes the second rail; "L" denotes the lower rails or those below the "B" rail; "U" denotes that the ingot position of the rail is unknown.

7. To convert tons into track miles, the number of tons may be divided by the figures given below, which show the tons (2,240 lbs.) of rail per mile of single track for different weights per yard of rail.

70-lb	110.00 tons	100-lb	157.14 tons
72-lb	113.14 tons	101-lb	158.71 tons
75-lb	117.86 tons	105-lb	165.00 tons
80-lb	125.71 tons	110-lb	172.86 tons
85-lb	133.67 tons	120-lb	188.57 tons
90-lb	141.43 tons	125-lb	196.43 tons
91-lb	143.00 tons		

8. Each line for the different rail lots should be completely filled in without the use of ditto marks. Use india ink or black typewriter ribbon and black carbon. Blueprints can thus be made and each strip formed by cutting along the horizontal lines will contain complete information for the lot it covers.

9. Opposite the lines "This Year" only the failures for the year ending October 31st, should be shown, and opposite the lines "Total to Date," all failures from date laid to October 31st.

10. In case of doubt as to the interpretation of this form or any of its items, write to Engineer of Tests, Rail Committee, American Railway Engineering Association, 900 South Michigan Avenue, Chicago, Ill.

11. This form, when filled out, should be returned to W. F. Allen, General Secretary, American Railway Association, 75 Church Street, New York City.

Form M. W. 409.

A. B. & C. R. R. CO.

SUMMARY OF STEEL RAIL FAILURES FOR A PERIOD OF YEARS.

Record for period of______years ending________19____ ______________Division

_____lb.________Section______________Steel. Rolled by______________Steel Co

Year Rolled	Tons of New Rail Laid Even Tons	Number of Rails which have failed each year during life of Rail																				Total	Lines
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
																							1
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(Cover Page for Forms M. W. 408, 409.)

Form M. W. 412.

A. B. & C. R. R. Co.

______________________________Division

Numerical Record and Position in the Ingot of Steel Rails which have Failed in Service

on______________________________

Year____________________ to Year 19______

Office of CHIEF ENGINEER M. of W.
(or other officer)

Group V.

Form M. W. 413.

A ____________ shown in Red B ____________ shown in Yellow

Summary

Month and Year												
Kind of Rail	A	B	A	B	A	B	A	B	A	B	A	B
Total sq. in. abraded Ave. sq. in. abraded per Section Percentage of Area abraded to total Area of Head												

A. B. & C. R. R. Co.

____________________________ Division

Location Diagram

of

_______________________________________ Rails

Laid in 19 _____________ Removed in 19 ________

Between _________________ and ____________________

Office of Chief Engineer M. of W. ______________ R. R.

Scale 1 in. = 1 mile Date ____________________

Form M. W. 414.

A ______________ shown in Red B ______________ shown in Yellow

Summary

Month and Year												
Kind of Rail	A	B	A	B	A	B	A	B	A	B	A	B
Total sq. in. abraded												
Ave. sq. in. abraded per Section												
Percentage of Area abraded to total Area of Head												

A. B. & C. R. R. Co.

_______________________________ Division

Location Diagram

of

_______________________________________ Rails

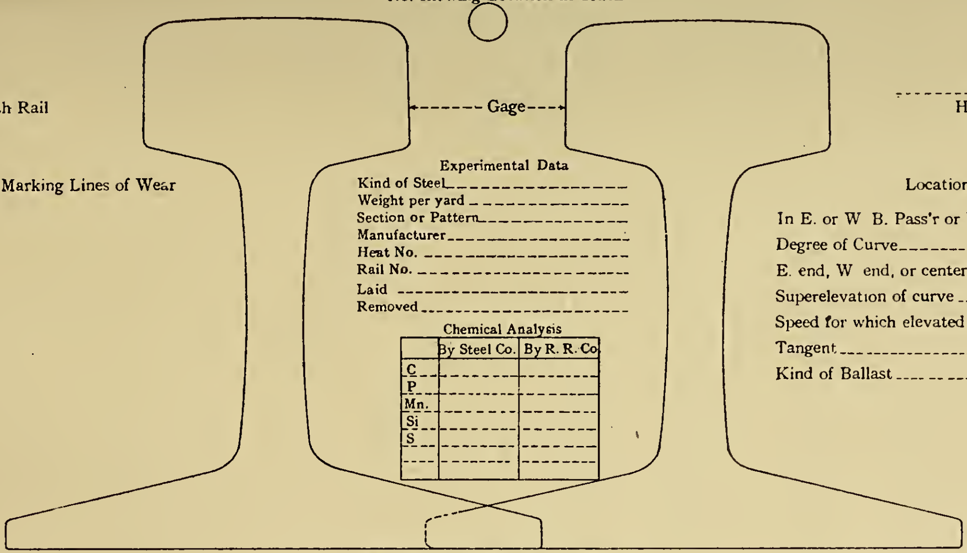
Laid in 19 ______________ Removed in 19 ______________

Between ________________ and ____________________

Office of Chief Engineer M. of W. ______________ R. R.

Scale 2 in. = 1 mile Date ______________________

No. showing Location in Track



Low or South Rail

Scheme of Marking Lines of Wear

High or North Rail

Experimental Data

Kind of Steel
Weight per yard
Section or Pattern
Manufacturer
Heat No.
Rail No.
Laid
Removed

Chemical Analysis

	By Steel Co.	By R. R. Co.
C		
P		
Mn.		
Si		
S		

Location Data

In E. or W B. Pass'r or Frt.
Degree of Curve
E. end, W end, or center of curve
Superelevation of curve
Speed for which elevated
Tangent
Kind of Ballast

Measurements taken at Rail Center

Measurements of Area Abraded

Date of Measurement	Sq. in. Abraded			
	Low Rail		High Rail	
	Area Abraded	Diff.	Area Abraded	Diff.

Div

Diagram Showing Lines of Wear
of
Rail

Laid in 19 Removed in 19
Between and
Office of Chief Engineer M of W R. R.
Scale, Full Size. Date

(Cover Page for Forms M.W. 413, 414, 415.)

Form M.W. 417

A. B. & C. R. R. Co.

______________________________Division

RAIL SECTIONS

Showing Progressive Wear
of

____________________and____________________Steel Rails.

Laid________________________ Removed________________________

Office of CHIEF ENGINEER M. of W.
(or other officer)

SPECIFICATIONS AND INSTRUCTIONS FOR USE OF FORMS M. W. 401 TO M. W. 418.

Size of sheet shown on each form.

GROUP I—REPORTS OF RAIL INSPECTION AND SHIPMENT AT THE MILL.

This set of forms is for the use of the railroad company's inspector at the mills where the rail is rolled. It gives all the information necessary to inform the purchaser that his order has been manufactured in accordance with the specifications and shipped.

M. W. 401-401A—Report of Mill Inspection:

This blank is filled out from the mill records under the supervision of the Inspector. It gives the chemical contents taken from the ladle analysis and the result of the drop test.

M. W. 402—Certificate of Inspection:

This is the Inspector's written statement that the material which he has witnessed rolled has been turned out strictly in accordance with the specifications and the order of the railway company.

M. W. 403—Report of Shipment:

This blank is used for reporting the number and length of rail shipped in each car from the works. When properly checked by the Receiving Officer, it furnishes the basis for payment of the bill.

M. W. 418—Tabulation of Results of Mill Inspection of Rails Rolled:

This form is intended for tabulating the results of drop test and surface inspection of rails rolled.

GROUP II—REPORTS FROM DIVISION OFFICERS.

This group contains all the regular reports which come from the division officers concerning the rails which have been put in service in track.

M. W. 404—Report of Rail Failures in Main Tracks:

This is the basic report of all rail failures and is sent by the Track Foreman to the Supervisor and by the latter transmitted to the Division Engineer. It contains a classification of rail failures which is used in the tabulations employed in the following blanks.

M. W. 405—Superintendent's Monthly Report of Rail Failures in Main Tracks:

On this blank the Division Engineer informs the Superintendent of the total number of rail failures for the month tabulated from the Track Foreman's report. Other officers who are interested such as the Chief Engineer, Chief Engineer of Maintenance of Way or General Superintendent, are furnished with copies. In cases where a copy of the Track Foreman's Report is sent to the Chief Engineer or Chief Engineer of Maintenance of Way, the monthly report serves as a check on the receipt of all individual rail reports.

M. W. 406—Annual Statement of Steel Rails Existing in Main Tracks:

This is an annual report sent by the Division Engineer to the Chief Engineer or Chief Engineer of Maintenance of Way for the permanent record of the company, showing the different kinds of steel in the main tracks at the end of the year. This statement may be used in conjunction with or may replace the rail chart, The rail chart may not be in convenient form for a permanent record which may be referred to, after many years, for information concerning the kind of rail in use at a stated period.

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[9] Adopted, Vol. 10, 1909, pp. 339-363, 375, 393-395; Vol. 11, Part 2, 1910, pp. 241-251, 576-579; Vol. 12, Part 1, 1912, pp. 467, 468; Part 2, pp. 17, 18; Vol. 14, 1913, pp. 188-192, 1104, 1105.

GROUP III—LABORATORY RAIL REPORT.

M. W. 407:

This group is, at present, represented by this single form. It is used for making check analyses against the mill analyses and for reporting the result of chemical analyses and physical test of special rail or other test pieces by the laboratory.

GROUP IV—COMPILATION OF RESULTS FOR STUDY.

This group exhibits the different ways for compiling quantitative statistics for rail failures.

M. W. 408—Summary of Steel Rail Failures for One Year:

This blank is intended for compiling the information relative to rail failures for a period of one year. It can also be used for other periods if found desirable, the total number of failures being reduced to "failures per 100 miles of track" in order to have a unit of comparison.

The column for "specified carbon" is intended for recording the analyses of the particular lot of rail as given in the specification. This column is inserted in this blank in order to give an idea as to whether the rail is high or low in carbon.

M. W. 409—Summary of Steel Rail Failures for a Period of Years:

On this blank the results from M. W. 408 will be recorded at the end of the year, thus making a continuous record of the rail during its entire life.

M. W. 412:

The information in this group should be bound together in one book. This cover has been provided for convenience and neatness.

GROUP V—PROGRESSIVE WEAR OF SPECIAL RAIL UNDER OBSERVATION.

In order to keep track of special rail, and determine the value of the results being given, it is necessary to have a systematic plan of procedure for examination and records. This group is furnished for that purpose, and is provided with a cover, as in the case of the previous group.

M. W. 413—Location Diagram:

This blank is on a scale one inch equals one mile, and is intended for diagrams showing the location in different places of the same kind of rail under trial.

M. W. 414—Location Diagram:

This blank is similar to M. W. 413, except that it is on a scale of two inches equals one mile and is intended to show the location of a particular portion of the rail given in M. W. 413. It is made on a larger scale so as to locate the points of measurement. A place is provided on each blank for the summary of the wear or area abraded in percentage of total area of head.

M. W. 415—Diagram Showing Lines of Wear:

The measuement of rail section at a specified point is shown on this blank and its position on M. W. 414 is given by the number in the circle in the center of the blank at the top. All statistical information of interest and importance is given on the blank.

M. W. 417:

The information in this group should be bound together in one book; this cover has been provided for convenience and neatness.

FORM M. W. 418.

TABULATION OF RESULTS OF MILL INSPECTION OF RAILS ROLLED.

M W 416

AMERICAN RAILWAY ENGINEERING ASSOCIATION

TABULATION OF RESULTS OF MILL INSPECTION OF RAILS ROLLED FROM.......... 191... TO .... 191...

	Report Numbers	Heat Numbers		Lines	Name of Company and Mill where Rolled	Rail			No. of Tons ordered	No. of Tons Accepted of each classification					No. of Tons Rejected		No. of Rails Rolled and submitted to Inspector for Acceptance.	No. of Rails Accepted and Classification				No. of Rails Rejected		Number of Rails rejected on account of																				No. of Rails accepted as No. 2 on account of exceeding specified deflection.		Ductility under 1st blow of Tup.										Ductility for 1 inch in one or more blows of Tup				Total Elongation in 6 inches at Failure				Average Analysis of Heats Accepted.							No. of passes from Ingot to Rail.	Shrinkage allowed in inches	Nominal discard from Ingots		Average No. of Ingots in Heat	Nominal No. of Rails per Ingot	Size of Ingot	No. of Heats Rolled	Heats showing Rails with interior defect.								Lines
										No. 1		No. 2		Total Tons	No.	% of total Rolled		No 1	No. 2	Total Rails		No.	% of total Rolled	b. (Top Rails) test piece (or pieces)						d. (Second Rails) test piece (or pieces)						f. (Third Rails) test piece (or pieces)						Surface imperfection		No.	% of total rejected	No. of Pieces Tested	Permanent set in inches			Elongation in inches						No. of Pieces Tested.	Total per cent elongation for 1 inch in one or more blows			No. of Pieces Tested	Maximum inches	Minimum inches	Average inches	C.	P.	Mn.	Si.	S.					% From Top	% From Bottom					In Top Rails		In 2nd. Rails		In 3rd. Rails		Totals		
										Tons	% of Total	Tons	% of Total					Rails	Rails	No.	% of total Rolled			Breaking		Failing in Ductility		Showing interior defect		Breaking		Failing in Ductility		Showing interior defect		Breaking		Failing in Ductility		Showing interior defect		No.	% of total rejected				Max.	Min.	Ave.	Per single inch			Total in 6 inches				Highest Max.	Lowest Max.	Average of the Maxima																				No. of Heats	% of total	No of Heats	% of total	No. of Heats	% of total	No. of Heats	% of total	
																								No.	% of total rejected	No.	% of total rejected	No.	% of total rejected	No.	% of total rejected	No.	% of total rejected	No.	% of total rejected	No.	% of total rejected	No.	% of total rejected	No.	% of total rejected									Highest Maximum	Lowest Maximum	Average of the Maxima	Max.	Min.	Ave.																																
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	
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These two columns are for office use in compiling the several rollings and shipments, and are to be removed on line "A" from the finished report.

IN COLUMN 4
B. - Bessemer.
O.H. - Open Hearth.
F.T. - Ferro-Titanium.

TESTS

17. One piece shall be tested from each heat of Bessemer steel.

(a) If the test piece does not break at the first blow and shows the required elongation (Section 14), all of the rails of the heat shall be accepted, provided that the test piece when nicked and broken does not show interior defect.

(b) If the piece breaks at the first blow, or does not show the required elongation (Section 14) or if the test piece shows the required elongation but when nicked and broken shows interior defect, all of the top rails from that heat shall be rejected.

(c) A second test shall then be made of a test piece selected by the inspector from the top end of any second rail of the same heat, preferably of the same ingot. If the test piece does not break at the first blow, and shows the required elongation (Section 14), all of the remainder of the rails of the heat shall be accepted, provided that the test piece when nicked and broken does not show interior defect.

(d) If the piece breaks at the first blow, or does not show the required elongation (Section 14), or if the piece shows the required elongation but when nicked and broken shows interior defect, all of the second rails from that heat shall be rejected.

(e) A third test shall then be made of a test piece selected by the inspector from the top end of any third rail of the same heat, preferably of the same ingot. If the test piece does not break at the first blow and shows the required elongation (Section 14), all of the remainder of the rails of the heat shall be accepted, provided that the test piece when nicked and broken does not show interior defect.

(f) If the piece breaks at first blow, or does not show the required elongation (Section 14), or if the piece shows the required elongation but when nicked and broken shows interior defect, all of the remainder of the rails from that heat shall be rejected.

18. Test pieces shall be selected from the second, middle and last full ingot of each Open-Hearth heat.

(a) If two of these test pieces do not break at the first blow and show the required elongation (Section 14), all of the rails of the heat shall be accepted, provided that these test pieces when nicked and broken do not show interior defect.

(b) If two of the test pieces break at the first blow, or do not show the required elongation, or if any of the pieces that have been tested under the drop when nicked and broken show interior defect, all of the top rails from that heat shall be rejected.

(c) Second tests shall then be made from three test pieces selected by the inspector from the top end of any second rails of the same heat, preferably of the same ingots. If two of these test pieces do not break at the first blow and show the required elongation (Section 14), all of the remainder of the rails of the heat shall be accepted, provided that the pieces that have been tested under the drop when nicked and broken do not show interior defect.

(d) If two of these test pieces break at the first blow or do not show the required elongation (Section 14), or if any of the pieces that have been tested under the drop when nicked and broken show interior defect, all of the second rails of the heat shall be rejected.

(e) Third tests shall then be made from three test pieces selected by the inspector from the top end of any third rails of the same heat, preferably of the same ingots. If two of these test pieces do not break at the first blow, and show the required elongation (Section 14), all of the remainder of the rails of the heat shall be accepted, provided that the pieces that have been tested under the drop when nicked and broken do not show interior defect.

(f) If two of these test pieces break at the first blow or do not show the required elongation (Section 14), or if any of the pieces, that have been tested under the drop when nicked and broken show interior defect, all of the remainder of the rails from that heat shall be rejected.

[10] REPORT OF STUDY OF AN INDIVIDUAL RAIL.

(1) A complete report of the study of an individual rail should consist of:

(*a*) Copy of the Track Foreman's report on Form M. W. 404, after being checked by an Engineer.

(*b*) Results of chemical analysis and physical test on Form M. W. 407.

(*c*) Photographs of the defect or fracture and micro-photographs of the interior structure.

(*d*) A complete written analysis or deduction from the study of the above information.

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[10] Adopted, Vol. 10, Part 1, 1909, pp. 340, 341, 348, 349, 353, 375, 393, 394, 395, 396.

COMMITTEE V.

TRACK.

[1] DEFINITIONS.

ALINEMENT.—The horizontal location of a railway with reference to curves and tangents.

CURVE, SIMPLE.—An arc of the circumference of a circle.

CURVE, DEGREE OF.—The angle subtended at the center of a simple curve by a 100-foot chord.

CURVE, COMPOUND.—A continuous change in direction of alinement by means of two or more contiguous simple curves of different degrees having a common direction at their junction points.

CURVE, REVERSE.—Two contiguous simple curves in opposite directions, with a common direction at their junction point.

CURVE, EASEMENT.—A curve whose degree varies either uniformly or in some definitely determined manner so as to give a gradual transition between a tangent and a simple curve, which it connects, or between two simple curves.

CURVE, VERTICAL.—A curve used to connect intersecting grade-lines.

CONNECTING TRACK.—Two turnouts with the track between the frogs arranged to form a continuous passage between one track and another intersecting or oblique track or another remote parallel track.

CROSSOVER.—Two turnouts with the track between the frogs, arranged to form a continuous passage between two nearby and generally parallel tracks.

CROSSOVER, DOUBLE.—A combination of two crossovers in opposite directions, which intersect between the parallel tracks.

ELEVATION (of Curves).—The vertical distance that the outer rail is raised above the inner rail, sometimes called Superelevation.

FASTENINGS.—Splice bars, bolts and spikes.

FASTENINGS, AUXILIARY.—Nutlocks, tie-plates, rail braces and anti-creeping devices.

FROG.—A device used where two rails intersect to permit engines and trains on one rail to cross the other.

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[1] Adopted, Vol. 5, 1904, pp. 527, 535, 541-560; Vol. 6, 1905, pp. 748, 749, 759-761; Vol. 10, Part 1, 1909, pp. 400, 461-463; Vol. 11, Part 2, 1910, pp. 942, 955; Vol. 16, 1915, pp. 728, 1144.

Frog Number.—One-half the cotangent of one-half the frog angle, or the number of units of length in which the spread is one unit.

Gage (a Tool).—A tool by which the gage of track is determined.

Gage (of Track).—The distance between the heads of the rails measured at right angles thereto at a point ⅝-inch below the top of the rail.

Gage, Standard.—The gage of 4 feet 8½ inches.

Level.—The condition of the track in which the elevation of the rails transversely is equal.

Line.—The condition of the track in regard to uniformity in direction over short distances on tangents, or uniformity in variation in direction over short distances on curves.

Lining Track.—Shifting the track laterally to conform to the established alinement.

Out of Face (referring to Track Work).—Work that proceeds completely and continuously over a given piece of track as distinguished from work at disconnected points only.

Scissors Crossover.—See "Crossover, Double."

Slip Switch.—A combination of one or two pairs of turnouts and a crossing where each pair of turnouts has a common curved lead and stock rail and the end frogs of the crossing serve for the turnout.

Spiral (when used with respect to Track).—A form of easement curve in which the change of degree of curve is uniform throughout its length.

Spiral, Ten-Chord.—An approximate spiral measured in ten equal chords and whose change of degree of curve is directly proportional to the length measured along the spiral by such chords.

Surface.—The condition of the track as to vertical evenness or smoothness over short distances.

Switch.—A device consisting of two movable rails, necessary connections and operating parts, designed to turn an engine or train from a track on which it is running to another track.

Tangent.—Any straight portion of a railway alinement.

Track.—Ties, rails and fastenings; with all parts in their proper relative positions.

Turnout.—A track device consisting of a switch and frog with connecting and operating parts and supporting ties by which engines and trains may be passed from one track to another. A turnout begins with the switch and ends with the switch ties, or with the frog where long ties are not used.

Wye.—A principal track and two connecting tracks arranged like the letter "Y," with the top closed, by means of which engines and trains may be turned.

[2] GAGE ON CURVES.

Curves eight degrees and under should be standard gage. Gage should be widened one-eighth inch for each two degrees or fraction thereof over eight degrees, to a maximum of 4 feet 9¼ inches for tracks of standard gage. Gage, including widening due to wear, should never exceed 4 feet 9½ inches.

Where frogs occur on the inside of curves the gage at the frog should be standard or the flangeway of the frog should be widened to compensate for the increased gage.

[3] WIDTH OF STANDARD FLANGEWAY.

The clear width of standard flangeway for all frogs and between main rails and guard rails should be 1¾ inches, measured at the gage line, for all tracks of 4 feet 8½ inches gage.

[4] TEMPERATURE EXPANSION FOR LAYING RAILS.

When laying rails their temperature should be taken by applying a thermometer. To allow for expansion the openings between the ends of adjacent 33-foot rails should be as follows:

TEMPERATURE. (Fahrenheit.)	ALLOWANCE.
—20° to 0°	5/16 inch
0° to 25°	¼ inch
25° to 50°	3/16 inch
50° to 75°	⅛ inch
75° to 100°	1/16 inch

Over 100 degrees rails should be laid close without bumping.

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[2] Adopted, Vol. 11, Part 2, 1910, pp. 942, 954, 955; Vol. 16, 1915, pp. 733, 1145.

[3] Adopted, Vol. 10, 1909, pp. 398, 466, 467.

[4] Adopted, Vol. 2, 1901, pp. 190, 212.

[5] STANDARD RAIL JOINT.

A standard rail joint should fulfill the following general requirements:

(1) It should connect the rails into a uniform continuous girder.

(2) It should be strong enough to resist deformation or taking permanent set.

(3) It should prevent relative deflection or vertical movement of the ends of the rails and permit movement lengthwise for expansion.

(4) It should be as simple and of as few parts as possible to be effective.

[6] DESIGN OF TRACK FASTENINGS.

Where there is material leakage from track circuits, track fastenings should be so designed as to prevent contact between the metal and the ballast.

[7] TIE-PLATES.

GENERAL PRINCIPLES TO BE FOLLOWED IN THE DESIGN.

Plates shall not be less than 6 inches in width, and as much wider as consistent with the class of ties to be used.

The length of the plates shall be not less than the safe bearing area of the ties divided by the width of the plate, and, when made for screw spikes, shall be so shaped as to provide proper support for the screw spikes.

The thickness of the plate shall be properly proportioned to the length.

Plates shall have a shoulder at least ½ of an inch high. The distance from the edge of rail base to the end of the tie-plate on the outer side must be uniform, and in excess of the projection inside of the rail base.

Where treated ties are used or where plates are for screw spikes, a flat bottom plate is preferable. Where ribs of any kind are used on base of plate, these shall be few in number and not to exceed ¼ inch in depth.

Punching must correspond to the slotting in the splice bars and, where advisable, may be so arranged that the plates may be used for joints. Spike holes may be punched for varying widths of rail base where the slotting will permit such punching without the holes interfering with each other and when the plate is of such design that the additional holes will not impair the strength of the plate.

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[5] Adopted, Vol. 7, 1906, pp. 655, 657; Vol. 16, 1915, pp. 729, 1145.

[6] Adopted, Vol. 11, Part 2, 1910, pp. 935, 942, 944.

[7] Adopted, Vol. 14, 1913, pp. 98, 1060.

[8] SPECIFICATIONS FOR STEEL TIE-PLATES.

Material.

Plates shall be made of Bessemer or open-hearth steel.

Physical Properties and Tests.

The tie-plates shall conform to the following requirements:

Ultimate strength, not less than 55,000 lbs. per square inch.

Elastic limit, not less than 50 per cent. of ultimate strength.

Elongation, not less than 20 per cent. in 2 inches.

Reduction of area, not less than 40 per cent.

Plates shall bend cold for 90 degrees without showing any sign of fracture.

A sufficient number of tests will be made to satisfy the inspector that the material meets the specifications in every respect.

Workmanship and Finish.

Subject to the following allowances, the form and dimensions of the plates shall conform to the drawings submitted to the manufacturer.

The length and width shall not vary more than 1/8 inch from the dimensions shown.

The thickness shall not vary more than 1/32 inch from the dimensions shown.

All variations in length shall be left on the inside end of the plate.

The distance from the shoulder to the outside end of the plate must be made uniform.

Spike holes must be clean cut, without burrs, and the plates must not be cracked or bent out of shape in punching the holes.

Plates must be properly and thoroughly annealed.

Plates must be stamped on the top side, outside of the rail seat, with the prescribed mark.

Plates shall be free from burrs and imperfections.

Inspection.

When required, the manufacturer shall furnish samples of tie-plates from a preliminary rolling before proceeding with the filling of the order and give sufficient notice in advance of the date when they will be ready for inspection.

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[8] Adopted, Vol. 14, 1913, pp. 98, 99, 1060, 1061.

The inspector representing the purchaser shall have free entry at all times, while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered.

The inspection shall be made at the mill and the manufacturer shall afford the inspector free of cost all reasonable facilities to satisfy himself that the plates are being furnished in accordance with these specifications. The tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Tests of the finished product shall be made of samples selected by the inspector from each lot of fifty bundles. Two pieces shall be selected for each test and if both meet the requirements of the specifications the lot will be accepted. If one of the test pieces fails a third test piece shall be selected and tested; if it meets the requirements of the specifications the lot will be accepted, but if it fails the lot will be rejected.

If, after shipment, any tie-plates are found to be defective, due to material or manufacture, they may be rejected.

Shipping.

Tie-plates shall be wired together in bundles of uniform number, weighing not to exceed 100 lbs., and properly tagged.

[9] SPECIFICATIONS FOR WROUGHT-IRON TIE-PLATES.

Material.

Plates shall be made of wrought-iron.

Physical Properties and Tests.

The ultimate strength shall be not less than 45,000 lbs. per square inch.

Plates shall bend cold for 90 degrees across the fiber without showing any sign of fracture.

A sufficient number of tests will be made to satisfy the inspector that the material meets the specifications in every respect.

Workmanship and Finish.

Subject to the following allowances, the form and dimensions of the plates shall conform to the drawings submitted to the manufacturer.

The length and width shall not vary more than ⅛ inch from the dimensions shown.

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[9] Adopted, Vol. 14, 1913, pp. 99, 100, 1060-1063.

The thickness shall not vary more than $\frac{1}{32}$ inch from the dimension shown.

Variations in length shall be left on the inside end of the plate.

The distance from the shoulder to the outside end of the plate must be made uniform.

Spike holes must be clean cut, without burrs, and the plates must not be cracked or bent out of shape in punching the holes.

Plates must be stamped on the top side, outside of the rail seat, with the prescribed mark.

Plates shall be free from burrs and imperfections.

Inspection.

When required, the manufacturer shall furnish samples of tie-plates from a preliminary rolling before proceeding with the filling of the order and give sufficient notice in advance of the date when they will be ready for inspection.

The inspector representing the purchaser shall have free entry at all times, while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered.

The inspection shall be made at the mill and the manufacturer shall afford the inspector free of cost all reasonable facilities to satisfy himself that the plates are being furnished in accordance with these specifications. The tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Tests of the finished product shall be made of samples selected by the inspector from each lot of fifty bundles. Two pieces shall be selected for each test and if both meet the requirements of the specifications the lot will be accepted. If one of the test pieces fails a third test piece shall be selected and tested; if it meets the requirements of the specifications the lot will be accepted, but if it fails the lot will be rejected.

If, after shipment, any tie-plates are found to be defective due to material or manufacture, they may be rejected.

Shipping.

Tie-plates shall be wired together in bundles of uniform number, weighing not to exceed 100 lbs., and properly tagged.

[10] SPECIFICATIONS FOR MALLEABLE TIE-PLATES.

Material.

Plates shall be made from furnace malleable iron.

Physical Properties and Tests.

Plates must be cast with a lug for test purposes. The test lug when broken off must not break easily, as cast-iron, but must bend and show signs of toughness. The fracture must show a narrow band of white metal on the surface, center portion being dark and fiberless.

Plates must bend sufficiently to show thorough annealing.

A sufficient number of tests will be made to satisfy the inspector that the material meets the specifications in every respect.

Workmanship and Finish.

Subject to the following allowances, the form and dimensions of the plate shall conform to the drawings submitted to the manufacturer.

The length and width shall not vary more than $\frac{1}{16}$ inch from the dimensions shown.

The thickness shall not vary more than $\frac{1}{32}$ inch from the dimension shown.

Plates must be properly and thoroughly annealed.

Plates must be well cleaned and free from warping, shrinkage cracks, blowholes, fins, and other imperfections.

Inspection.

When required, the manufacturer shall furnish samples of tie-plates from a preliminary lot before proceeding with the filling of the order and give sufficient notice in advance of the date when they will be ready for inspection.

The inspector representing the purchaser shall have free entry at all times, while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered.

The inspection shall be made at the mill and the manufacturer shall afford the inspector free of cost all reasonable facilities to satisfy himself that the plates are being furnished in accordance with these specifications. The tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

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[10] Adopted, Vol. 14, 1913, pp. 100, 101, 1063.

If, after shipment, any tie-plates are found to be defective, due to material or manufacture, they may be rejected.

Shipping.

Tie-plates shall be wired together in bundles of uniform number, weighing not to exceed 100 lbs., and properly tagged.

[11] TRACK BOLTS.

FACTS AND GENERAL PRINCIPLES TO BE TAKEN INTO CONSIDERATION IN THE DESIGN.

As a rule, as large track bolts should be used as the rail and splice bars will permit.

Bolts with rolled threads show a greater ultimate strength than those of the same size with cut threads. The elastic limit, however, is not materially different.

A workman pulling on a 33-inch wrench with a pull of 100 lbs. will load a ⅞-inch diameter bolt to the extent of 45,000 lbs. per square inch where the threads are in average condition. Therefore, it is easy to see how a bolt with a low elastic limit will readily be stretched in being tightened.

A ⅞-inch bolt with an elastic limit of 45,000 lbs. will require the same pull to stretch it as a 1-inch bolt with an elastic limit of 35,000 lbs. Again, a 1-inch bolt with an elastic limit of 75,000 lbs. requires over twice the pull to stretch it as a 1-inch bolt with an elastic limit of 35,000 lbs.

[12] SPECIFICATIONS FOR TRACK BOLTS.

Material.

Steel shall be made by the open-hearth or other approved process. If necessary to secure the properties desired the bolts may be heat-treated.

Physical Properties and Tests.

Bolts shall conform to the following requirements:

For carbon steel:

Elastic limit,	not less than 35,000 lbs. per square inch.
Elongation,	not less than 25 per cent. in 2 inches.
Reduction of area,	not less than 50 per cent.

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[11] Adopted, Vol. 14, 1913, pp. 101, 102, 1063.

[12] Adopted, Vol. 14, 1913, pp. 102, 103, 1064.

For untreated nickel or other alloy steel:

Elastic limit,	not less than 45,000 lbs. per square inch
Elongation,	not less than 20 per cent. in 2 inches.
Reduction of area,	not less than 40 per cent.

For heat-treated nickel or other alloy steel:

Elastic limit,	not less than 75,000 lbs. per square inch.
Elongation,	not less than 15 per cent. in 2 inches.
Reduction of area,	not less than 40 per cent.

Elastic limit shall in no case be less than 50 per cent. of the ultimate strength.

The elastic limit, elongation and reduction of area may be determined on a finished bolt or on a test piece ½x2 inches turned from a finished bolt.

The ductility of the bolts shall be determined by the cold bend test, which requires that the material used in the bolts shall bend cold through 180 degrees and flatten itself without fracture on the outside of the bent portion. This bend may be made on the unthreaded portion of a finished bolt, on a blank bolt or on a test piece of the same size and same grade of steel, in any case, subjected to the same treatment as the finished bolt. It is not necessary that the bolt bend double in the threaded portion.

A sufficient number of tests shall be made to satisfy the inspector that the material meets the specifications in every respect.

Workmanship and Finish.

Subject to the following allowances, track bolts shall conform to the drawing submitted to the manufacturer:

The length shall not be more than $\frac{1}{16}$ inch less or ⅛ inch more than the dimension shown.

The diameter of the bolt shall not vary more than $\frac{1}{64}$ inch from the dimension shown.

The size of the head shall not vary more than $\frac{1}{16}$ inch from the dimensions shown.

The outside dimensions of the nut shall not vary more than $\frac{1}{32}$ inch from the dimensions shown.

The shoulder of the bolt shall not vary more than $\frac{1}{64}$ inch from the dimensions shown.

The heads and nuts shall be free from checks or burrs of any kind. They shall have the U. S. standard upset thread unless otherwise specified. The threads may be either cut or rolled and shall be full and clean, with not less than two, nor more than five, finger threads.

Care must be taken to avoid damage to the metal by overheating in manufacture.

Inspection.

When required, the manufacturer shall furnish samples of bolts from a preliminary rolling before proceeding with the filling of the order and give sufficient notice in advance of the date when they will be ready for inspection.

The inspector representing the purchaser shall have free entry at all times, while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered.

The inspection shall be made at the mill and the manufacturer shall afford the inspector free of cost all reasonable facilities to satisfy himself that the bolts are being furnished in accordance with these specifications. The tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Tests of the finished product shall be made of samples selected by the inspector from each lot of 100 packages. Two pieces shall be selected for each test and if both meet the requirements of the specifications the lot will be accepted. If one of the test pieces fails a third test piece shall be selected and tested; if it meets the requirements of the specifications the lot will be accepted, but if it fails the lot will be rejected.

If, after shipment, any bolts are found to be defective due to material or manufacture, they may be rejected.

Marking and Shipping.

When the bolts are shipped they shall have the nuts applied for at least two threads, shall be properly oiled to prevent rusting and shall be packed in good, serviceable packages. All packages must be plainly marked as to material, size of bolts and name of manufacturer.

[13] SPECIFICATIONS FOR SPIRAL SPRING NUTLOCKS.

Material.

Steel from which the nutlocks are made must be of open-hearth steel, or other approved process, and shall conform to the following chemical analysis:

Phosphorus, not over .05 per cent.
Sulphur, not over .05 per cent.

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[13] Adopted, Vol. 14, 1913, pp. 103, 104, 105, 1064, 1065.

Physical Properties and Tests.

After the finished nutlock has been subjected for one hour to pressure sufficient to compress it flat and has been released, its reaction shall be not less than two-thirds its height or thickness of section, provided thickness is less than width of section. If the section is square, the reaction must be not less than one-half its thickness. If height or thickness of section is more than width, the reaction shall be not less than the width of the section.*

With one end of the finished nutlock secured in a vise, and the opposite end twisted to 45 degrees, there must be no sign of fracture. When further twisted until broken, the fracture must show a good quality of steel.

A sufficient number of tests will be made to satisfy the inspector that the material meets the specifications in every respect.

Workmanship and Finish.

The dimensions and form of the nutlock shall conform to the drawings submitted to the manufacturer.

Nutlocks shall be clean, without burrs or rough edges. The coil and cross-section shall be uniform throughout.

The manufacturer is required to guarantee:

(1) That the steel was thoroughly annealed and permitted to assume its proper molecular structure before being made into nutlocks.

(2) That the subsequent heat treatment was scientifically accurate according to the best methods known, to secure uniformity of temper and the highest efficiency attainable.

Inspection.

When required, the manufacturer shall furnish samples of nutlocks from a preliminary lot before proceeding with the filling of the order, and give sufficient notice in advance of the date when they will be ready for inspection.

The inspector representing the purchaser shall have free entry at all times, while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered.

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* Note.—The internal diameters naturally affect the percentage of reaction, and the above specifications apply to nutlocks of internal diameters from $\frac{13}{16}$ inch to $1\frac{5}{16}$ inches. Owing to the difficulty of establishing a common rate of percentage that shall be uniformly applicable to any internal diameter of any nutlock of any section, it has been sought to cover the matter as above. Amount and durability of reactionary power under constant pressure is the true test of any spiral spring nutlock. The percentage of reaction increases proportionately with the increased internal diameter of any given section.

The inspection shall be made at the mill and the manufacturer shall afford the inspector free of cost all reasonable facilities to satisfy himself that the nutlocks are being furnished in accordance with these specifications. The tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Tests of the finished product shall be made of samples selected by the inspector from each separate heat treatment. Two pieces shall be selected for each test and if both meet the requirements of the specifications the lot will be accepted. If one of the test pieces fails a third test piece shall be selected and tested; if it meets the requirements of the specifications the lot will be accepted, but if it fails the lot will be rejected.

If, after shipment, any nutlocks are found to be defective due to material or manufacture, they may be rejected.

Marking and Shipping.

When nutlocks are shipped they shall be packed in good, serviceable packages. All packages must be plainly marked as to material, size and number contained therein, and the name of the manufacturer.

[14] SPECIFICATIONS FOR ORDINARY TRACK SPIKES.

Material.

Steel shall be made by the open-hearth or other approved process. If necessary to secure the properties desired, the spikes may be heat-treated.

Physical Properties and Tests.

Spikes shall conform to the following requirements:

Ultimate strength,	not less than 55,000 lbs. per square inch.
Elastic limit,	not less than 50 per cent. of ultimate strength.
Elongation,	not less than 20 per cent. in 2 inches.
Reduction of area,	not less than 40 per cent.

The finished spike, when bent back on itself through 180 degrees and hammered down, shall show no signs of fracture.

When the head of the spike is bent backward cold it shall show no signs of fracture.

When the body of the spike is twisted cold 1½ turns it shall show no signs of fracture.

A sufficient number of tests will be made to satisfy the inspector that the material meets the specifications in every respect.

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[14] Adopted, Vol. 14, 1913, pp. 105, 106, 1064, 1065.

Workmanship and Finish.

Subject to the following allowances, the form and dimensions of the spike shall conform to the drawings submitted to the manufacturer.

Thickness shall not vary more than $\frac{1}{32}$ inch from the dimensions shown.

Length under the head shall be not less, nor over $\frac{1}{4}$ inch more, than the dimension shown.

Thickness of the head shall not vary more than $\frac{1}{16}$ inch from the dimensions shown.

The angle of the hook shall not vary more than one degree from that shown on the drawing.

Spikes must be neatly formed, free from burrs and rough edges, and have well-shaped heads and sharp points.

Inspection.

When required, the manufacturer shall furnish samples of spikes from a preliminary rolling before proceeding with the filling of the order and give sufficient notice in advance of the date when they will be ready for inspection.

The inspector representing the purchaser shall have free entry at all times, while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered.

The inspection shall be made at the mill and the manufacturer shall afford the inspector free of cost all reasonable facilities to satisfy himself that the spikes are being furnished in accordance with these specifications. The tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Tests of the finished product shall be made of samples selected by the inspector from each lot of 100 packages. Two pieces shall be selected for each test and if both meet the requirements of the specifications the lot will be accepted. If one of the test pieces fails a third test piece shall be selected and tested; if it meets the requirements of the specifications the lot will be accepted, but if it fails the lot will be rejected.

If, after shipment, any spikes are found to be defective due to material or manufacture, they may be rejected.

Marking and Shipping.

When spikes are shipped they shall be packed in good, serviceable packages. All packages must be plainly marked as to material, size of spikes and name of manufacturer.

[15] SPECIFICATIONS FOR SCREW SPIKES.

Material.

Screw spikes shall be made of open-hearth steel.

The chemical properties of the finished spike shall conform to the following limits:

Phosphorus,	not over .05 per cent.
Sulphur,	not over .05 per cent.

Physical Properties and Tests.

The finished spike shall conform to the following requirements:

Ultimate strength,	not less than 60,000 lbs. per square inch.
Elastic limit,	not less than 50 per cent. of ultimate strength.
Elongation,	not less than 22 per cent. in 2 inches.
Reduction of area,	not less than 40 per cent.

The material used in the spikes bent when cold through an angle of 180 degrees and hammered down shall show no signs of fracture.

The finished spike when bent cold through an angle of 90 degrees shall show no signs of fracture.

A sufficient number of tests will be made to satisfy the inspector that the material meets the specifications in every respect.

Workmanship and Finish.

The dimensions and form of the screw spike shall conform to the drawings submitted to the manufacturer.

Spikes shall be finished smooth and in a workmanlike manner, having no rough edges. They shall be of exact size, with symmetrical heads, the axis of which must be situated in the direct line of the shank axis produced.

Inspection.

When required, the manufacturer shall furnish samples of spikes from a preliminary rolling before proceeding with the filling of the order and give sufficient notice in advance of the date when they will be ready for inspection.

The inspector representing the purchaser shall have free entry at all times, while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered.

The inspection shall be made at the mill and the manufacturer shall afford the inspector free of cost all reasonable facilities to satisfy himself that the spikes are being furnished in accordance with these specifications. The tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

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[15] Adopted, Vol. 14, 1913, pp. 106, 107, 1065, 1066.

Tests of the finished product shall be made of samples selected by the inspector from each lot of 100 packages. Two pieces shall be selected for each test and if both meet the requirements of the specifications the lot will be accepted. If one of the test pieces fails a third test piece shall be selected and tested; if it meets the requirements of the specifications the lot will be accepted, but if it fails the lot will be rejected.

If, after shipment, any spikes are found to be defective due to material or manufacture, they may be rejected.

Marking and Shipping.

When spikes are shipped they shall be properly oiled to prevent rusting and shall be packed in good, serviceable packages. All packages must be plainly marked as to material, size of spike and name of manufacturer.

[16] ANTI-CREEPERS.

GENERAL REQUIREMENTS TO BE MET IN THE DESIGN AND MANUFACTURE.

Anti-creepers shall be so designed as to fit two or more different weights of rail and so that they can be readily removed and re-applied.

They must be easy to apply under full-ballasted track.

They must be substantial enough to stand driving to place without chance of breaking.

The least possible number of movable parts is desirable.

When applied they must be in position rigidly enough to carry the tie with them in any kind of ballast without slipping.

They shall be made with sufficient take-up to permit of proper tightening.

When in place they must not loosen sufficiently to render them inoperative when the rail slacks back.

Controlling or delicate parts should be made of non-rustable material.

Anti-creepers made of steel shall be of sufficient size to minimize their destruction by rust.

Anti-creepers made of malleable iron must be from furnace malleable iron properly annealed, and of sufficient weight to prevent breakage and distortion in application or in service.

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[16] Adopted, Vol. 14, 1913, pp. 107, 1066.

[17]DESIRABLE AGENCIES TO OBTAIN A BETTER CLASS OF SECTION FOREMEN.

The following principles are recommended as desirable agencies to secure a better class of section foremen:

(1) The application of the principle of apprenticeship for a defined period during which the rate of pay shall be the same as that of a laborer, and following which those men who show the necessary qualities for foremen shall be given an increase in compensation and the title of assistant foreman. From this position these men should be promoted to that of section foreman.

(2) The application of a method of education which contemplates periodical meetings, at which supervising officers shall instruct concerning practice and shall encourage discussion among the men.

(3) The application where possible of an educational system, such as is in use on several of the larger railways. In this system articles dealing with the best practices are written by supervising officers and are printed and sent to foremen and assistant foremen free of cost. Later an examination is conducted on the results of which promotion depends.

[18]MAINTENANCE OF LINE.

(a) Tangents.

Tangents should be adjusted between summits and between curves; or by throwing curves to meet tangents; or by partially throwing curves and partially throwing tangents as may require the least work. Centers should be set with transit to secure accurate line.

(b) Curves; Use of Easement Curves.

Easement curves should be used with all curves requiring an elevation of 2 inches or more for the highest permissible speed.

The choice of easement curves should be governed by the ultimate speed possibilities, considering probable revision of the worst features of alinement, rather than by existing schedule speed.

With curves of 6 degrees and over, which are speed-limiting curves, easement curves should be not less than 240 feet long.

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[17] Adopted, Vol. 14, 1913, pp. 108-109, 130, 1058, 1059.

[18] Adopted, Vol. 3, 1902, pp. 55, 56, 67-78; Vol. 5, 1904, pp. 527, 528, 535, 561, 562; Vol. 6, 1905, pp. 753, 754, 759-761; Vol. 10, Part 1, 1909, pp. 400, 429, 430, 461-463, 464; Vol. 12, Part 1, 1911, pp. 402, 447; Vol. 16, 1915, pp. 731, 1145.

With speed-limiting curves of less than 6 degrees, easement curves should have lengths in feet of not less than 5⅓ times the speed in miles per hour calculated for an elevation of 8 inches.

With curves which are not likely to limit speed, easement curves should have lengths in feet of not less than thirty times the elevation in inches for the ultimate speed, nor less than two-thirds the ultimate speed in miles per hour times the elevation in inches.

Longer easement curves than the minimum lengths thus determined may be used to advantage and will be convenient sometimes, but any considerable increase in length is wholly unnecessary and should never be made without careful consideration of the effect on cost. For minor curves an increase in length of about 50 per cent. over the minimum is recommended when such increase will not seriously affect the cost nor adversely affect the degree of curve. The minimum lengths should be used in all cases where greater lengths would adversely affect the degrees of main curves.

Curve elevations should be attained and run out uniformly over the full length of easement curves with no elevation on tangents and full elevation on circular curves.

Easement curves should be used between curves of different degrees, and change of elevation should be effected just as between curves and tangents.

Any form of easement curve is satisfactory:

(1) In which the rate of increase in degree of curve can readily be changed to suit particular cases so that the length of easement curve shall be the same as the distance in which the outer rail is raised from nothing to full elevation.

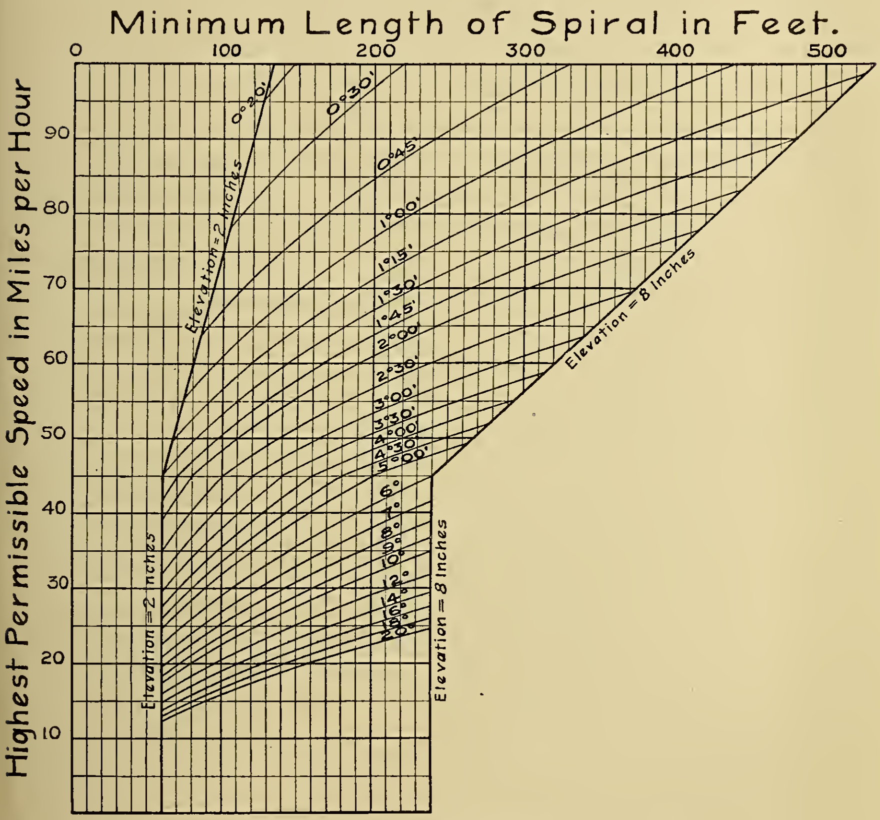
(2) Which can be run in by deflection or offset with chords of any desired length.

(3) Which is of the general type of either the Searles spiral, the cubic parabola, or the Holbrook, Crandall, Talbot, and 10-chord spiral.

The 10-chord spiral is recommended. Chords of any part of the spiral length may be used in staking out the 10-chord spiral when the central angle is small. To secure the most accurate results chords approximately one-tenth the length of spiral should be used when the central angle exceeds 15 degrees.

(c) Permanent Monuments.

Permanent monuments should be placed at points of tangent, points of spiral, points of change of curvature, summits, and at such other points along curves or tangents as will enable the alinement to be identically reproduced with a transit.



MINIMUM LENGTH OF EASEMENT CURVE.

Limiting Curves.

For all curves which are liable to limit the speed of trains, the length of spiral should equal that indicated on the line marked "Elevation = 8 inches." Longer spirals may be used provided the increased length does not adversely affect the degree of curve or seriously affect the cost of construction.

Minor Curves.

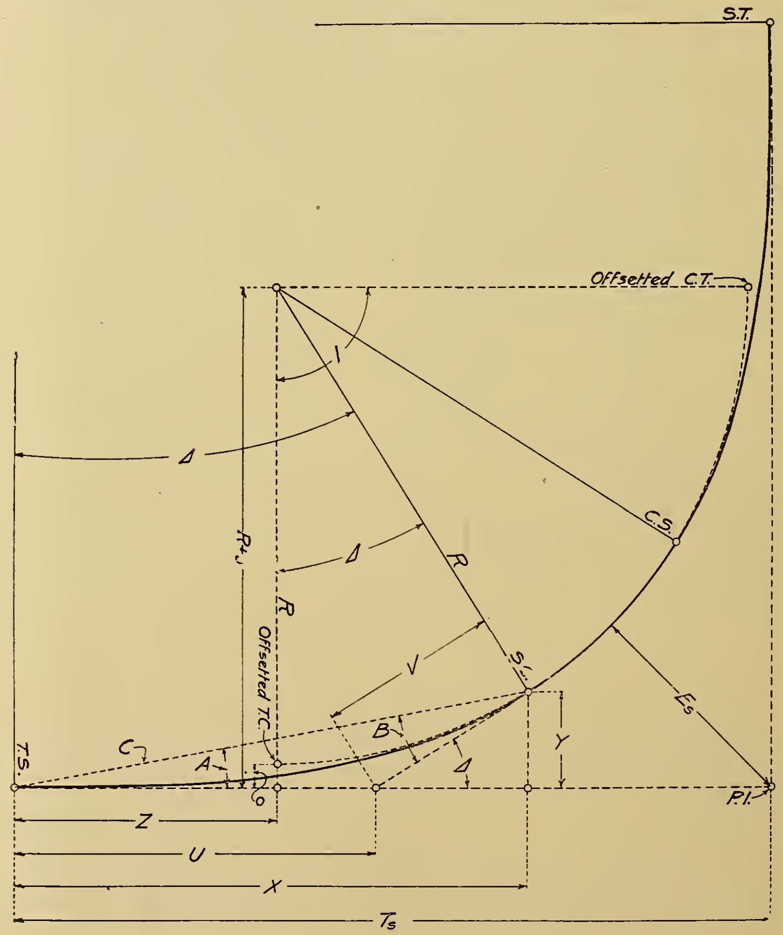
For minor curves the length of spiral should never be less than that indicated by the diagram; an increase of about 50 per cent. over the indicated length may be desirable where cost is not seriously affected.

Spirals need not be used when elevation required for highest permissible speed is less than two inches.

[19] SPIRALS.

NOTATION.

For curve points, the first initial represents the alinement on the side toward station zero, the second that away from station zero.



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[19] Adopted, Vol. 12, Part 1, 1911, pp. 418, 464; Vol. 16, 1915, pp. 731, 1145.

T. C.	The point of change in alinement from tangent to circular curve.
C. T.	The point of change from circular curve to tangent.
C. C.	The point of change in degree of circular curve; the point of compound curve, the point of reverse curve.
T. S.	The point of change from tangent to spiral.
S. C.	The point of change from spiral to circular curve.
C. S.	The point of change from circular curve to spiral.
S. T.	The point of change from spiral to tangent.
S. S.	The point of change from one spiral to another.

The symbols *T. C.* and *C. T.*, *T. S.* and *S. T.*, and *S. C.* and *C. S.* become transposed when the direction of stationing is changed.

a	The angle between the tangent at the *T. S.* and the chord from the *T. S.* to any point on the spiral.
A	The angle between the tangent at the *T. S.* and the chord from the *T. S.* to the *S. C.*
b	The angle at any point on the spiral, between the tangent at that point and the chord from the *T. S.*
B	The angle at the *S. C.* between the chord from the *T. S.* and the tangent at the *S. C.*
c	The chord from the *T. S.* to any point on the spiral.
C	The chord from the *T. S.* to the *S. C.*
d	The degree of curve at any point on the spiral.
D	The degree of central circular curve.
f	The angle between any chord of the spiral (produced if necessary) and the tangent through the *T. S.*
I	The angle between the initial and final tangents; the total central angle of circular curve and spirals.
k	The increase in degree of curve per station on the spiral.
l	The length of the spiral in feet from the *T. S.* to any given point.
L	The length of the spiral in feet from the *T. S.* to the *S. C.*
o	The ordinate of the offset *T. C.*; the distance between the tangent and a parallel tangent to the offset curve.
r	The radius of the osculating circle at any given point of the spiral.
R	The radius of the central circular curve.
s	The length of the spiral in stations from the *T. S.* to any given point.
S	The length of the spiral in stations from the *T. S.* to the *S. C.*
u	The distance on the tangent from the *T. S.* to the intersection with a tangent through any given point of the spiral.

U	The distance on the tangent from the *T. S.* to the intersection with a tangent through the *S. C.*; the longer spiral tangent.
v	The distance on the tangent through any given point from that point to the intersection with the tangent through the *T. S.*
V	The distance on the tangent through the *S. C.* from the *S. C.* to the intersection with the tangent through the *T. S.*; the shorter spiral tangent.
x	The abscissa or tangent distance of any given point, referred to the *T. S.*
X	The abscissa or tangent distance of the *S. C.*, referred to the *T. S.*
y	The ordinate or tangent offset of any point on the spiral.
Y	The ordinate or tangent offset of the *S. C.*
Z	The abscissa or tangent distance of the offset *T. C.*, referred to the *T. S.*
δ	The central angle of the spiral from the *T. S.* to any given point.
Δ	The central angle of the whole spiral.
Ts	The tangent distance of the spiraled curve; distance from *T. S.* to *P. I.* (point of intersection of tangents).
Es	The external distance of the offset curve.

FORMULAS FOR THE EXACT DETERMINATION OF THE FUNCTIONS OF THE TEN-CHORD SPIRAL WHEN THE CENTRAL ANGLE DOES NOT EXCEED 45 DEGREES.

$$\left.\begin{aligned} d = ks = \frac{kl}{100} \\ D = kS = \frac{kL}{100} \end{aligned}\right\} \dots\dots\dots\dots (1)$$

$$\left.\begin{aligned} \delta = \frac{ks^2}{2} = \frac{ds}{2} = \frac{kl^2}{20000} = \frac{dl}{200} \\ \Delta = \frac{kS^2}{2} = \frac{DS}{2} = \frac{kL^2}{20000} = \frac{DL}{200} \end{aligned}\right\} \dots\dots\dots\dots (2)$$

$$A = \tfrac{1}{3}\Delta - 0.00297\,\Delta^3 \textit{ seconds} \dots\dots\dots\dots (3)$$

$$B = \Delta - A \dots\dots\dots\dots (4)$$

$$C = L\,(\cos 0.3\,\Delta + .004 \operatorname{exsec} \tfrac{3}{4}\,\Delta) \dots\dots\dots\dots (5)$$

$$X = C \cos A \dots\dots\dots\dots (6)$$

$$Y = C \sin A \dots\dots\dots\dots (7)$$

$$U = C\frac{\sin B}{\sin \Delta} \dots\dots\dots\dots (8)$$

$$V = C\frac{sin\ A}{sin\ \Delta} \tag{9}$$

$$R = \frac{50}{sin\ \tfrac{1}{2} D} \tag{10}$$

$$Z = X - R\ sin\ \Delta \tag{11}$$

$$o = Y - R\ vers\ \Delta \tag{12}$$

$$T_s = (R + o)\ tan\ (\tfrac{1}{2} I) + Z \tag{13}$$

$$E_s = (R + o)\ exsec\ (\tfrac{1}{2} I) + o \tag{14}$$

FORMULAS FOR FIELD USE.

The formulas presented above are best adapted for the preparation of tables. For use in the field, the following empirical formulas are sufficiently accurate and have the advantage that they do not require the computation of the long chord. The formulas can all be applied for the functions of any parts of the spiral without serious error, though they are derived for the completed spiral.

$$\left.\begin{array}{l} a = \tfrac{1}{3}\delta \\ A = \tfrac{1}{3}\Delta \end{array}\right\} \tag{15}$$

$$\left.\begin{array}{l} a = 10\ ks^2\ minutes \\ A = 10\ kS^2\ minutes \end{array}\right\} \tag{16}$$

Formulas (15) and (16) are sufficiently accurate for turning deflections when δ (or Δ) does not exceed 15 degrees.

A similar approximation may be used when the transit is set at an intermediate point on the spiral if the included central angle from the transit point to the point of sight, less the included angle from the *T. S.* to the transit point, does not exceed 15 degrees.

$$X = L - L\ (\tfrac{1}{3}\ vers\ \tfrac{3}{4}\ \Delta + {}^{1}/_{22}\ vers\ \tfrac{1}{2}\ \Delta) \tag{17}$$

$$Y = \frac{L}{39}(20\ sin\ \tfrac{1}{2}\ \Delta + 3\ sin\ \Delta) \tag{18}$$

$$U = L\ (\tfrac{2}{3} + {}^{10}/_{39}\ exsec\ \tfrac{1}{2}\ \Delta + {}^{1}/_{10}\ vers\ \tfrac{1}{4}\ \Delta) \tag{19}$$

$$V = L\ (\tfrac{1}{3} + {}^{10}/_{39}\ exsec\ \tfrac{1}{2}\ \Delta) \tag{20}$$

$$o = \frac{L}{10}(sin\ \tfrac{1}{2}\ \Delta + sin\ \tfrac{1}{3}\ \Delta)\ cos\ \tfrac{1}{2} D \tag{21}$$

$$Z = L\ (0.5 - .12885\ vers\ \tfrac{1}{2}\ \Delta) - .073\ D\ sin\ \Delta \tag{22}$$

$$L = \frac{370.82}{cos\ {}^{21}/_{60}\ D}\ (1 + .000018\ Do)\sqrt{\frac{o}{D}} \tag{23}$$

STAKING SPIRALS BY OFFSETS.

The spiral may be staked by offsets, one-half being offset from the tangent and the other half from circular curve, by making the offsets vary directly as the cube of the distance from the *T. S.* and the *S. C.* This should be done either by using right angle and normal offsets, making the right angle or normal offset for the middle point of the spiral equal one-half *o;* or else by measuring half the total length of the spiral along the tangent, bisecting the distance to the offset *T. C.* for the offset to the middle point of spiral and using oblique offsets between equidistant points on the tangent or circular curve and equidistant points on the spiral.

Both methods will produce spirals somewhat at variance with any theoretical curve, but the variations are of no practical consequence.

If closer adherence to the theoretical curve is desired, the entire spiral may be staked from the tangent by use of the coördinate x and y.

STAKING SPIRALS BY DEFLECTIONS.

While any length of chord may be used in staking the spiral, either by offsets or deflections, the most accurate results are obtained by the use of ten equal chords, which is frequently the most convenient method when through-line stationing is not used.

If the spiral be divided into ten equal chords, the first deflection in minutes equals the degree of the main curve times the length of the chord in stations; *e. g.,* when $L = 500$ and $D = 4$, $s_1 = 0.5$ and $a_1 = \mathrm{d}$ times $0.5 = 2$ minutes. The remaining deflections are as the squares of the chord numbers, or 4, 9, 16, etc., times the first deflection.

The same limitations apply to these deflections as well as deflections derived from the table of coefficients, as apply to the use of formulas (15) and (16).

When Δ exceeds 15 degrees, formula (3) should be used or else an additional transit point used between the *T. S.* and the *S. T.*

In the latter case the deflection angle from a tangent through a point P' to a point P'' is the deflection for the degree of curve at P' for the distance P' P'' plus or minus the initial spiral deflection angle for the distance P' P''.

This rule applies equally to spirals run in from any point on spiral, from the *S. T.,* or to a spiral connecting two circular curves, the latter being simply the requisite portion of the ordinary spiral. The rule is approximate and should not be used when the central angle from P' to P'' exceeds the central angle from the *T. S.* to P' by more than 15 degrees.

The following table gives the coefficient by which the first chord deflection is to be multiplied to give the deflection to other chord points for various positions of the transit.

COEFFICIENTS OF a_1 FOR DEFLECTION ANGLES TO CHORD POINTS

Deflection Angle to Chord Point Number	Transit at Chord-Point Number										
	0 *T. S.*	1	2	3	4	5	6	7	8	9	10 *S. C.*
0 *T.S.*	0	2	8	18	32	50	72	98	128	162	200
1	1	0	5	14	27	44	65	90	119	152	189
2	4	4	0	8	20	36	56	80	108	140	176
3	9	10	7	0	11	26	45	68	95	126	161
4	16	18	16	10	0	14	32	54	80	110	144
5	25	28	27	22	13	0	17	38	63	92	125
6	36	40	40	36	28	16	0	20	44	72	104
7	49	54	55	52	45	34	19	0	23	50	81
8	64	70	72	70	64	54	40	22	0	26	56
9	81	88	91	90	85	76	63	46	25	0	29
10 *S.C.*	100	108	112	112	108	100	88	72	52	28	0

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.

The following table gives values of the deflection angle A for values of Δ varying by tenths of degrees, and for the same values of Δ it gives coefficients of L for obtaining the long chord C, the coördinates X and Y to the end of the spiral and the spiral tangents U and V; also coefficients of L and D for obtaining the coördinates of o and Z of the offset point of curve.

To obtain any desired quantity in feet, knowing D and choosing a proper value of L, or choosing a value of k which will give a proper value for L and determining L from formula (1), derive Δ from equation (2). Opposite Δ find the tabulated value of the coefficient for the desired quantity and multiply it by L. For o and Z apply the coefficients as indicated in the column heading.

Interpolate when necessary.

For the functions of any intermediate point on the spiral as x, y. etc., proceed exactly in the same manner as for the completed spiral.

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
0.0°	0° 00′ 00″	1.000 000	1.000 000	.000 000
0.1°	0° 02′ 00″	1.000 000	1.000 000	.000 582
0.2°	0° 04′ 00″	.999 999	.999 999	.001 164
0.3°	0° 06′ 00″	.999 999	.999 997	.001 745
0.4°	0° 08′ 00″	.999 998	.999 995	.002 327
0.5°	0° 10′ 00″	.999 997	.999 992	.002 909
0.6°	0° 12′ 00″	.999 995	.999 989	.003 491
0.7°	0° 14′ 00″	.999 993	.999 985	.004 072
0.8°	0° 16′ 00″	.999 991	.999 981	.004 654
0.9°	0° 18′ 00″	.999 989	.999 975	.005 236
1.0°	0° 20′ 00″	.999 987	.999 970	.005 818
1.1°	0° 22′ 00″	.999 984	.999 963	.006 399
1.2°	0° 24′ 00″	.999 981	.999 956	.006 981
1.3°	0° 26′ 00″	.999 977	.999 949	.007 563
1.4°	0° 28′ 00″	.999 974	.999 941	.008 145
1.5°	0° 30′ 00″	.999 970	.999 932	.008 726
1.6°	0° 32′ 00″	.999 966	.999 922	.009 308
1.7°	4° 34′ 00″	.999 961	.999 912	.009 890
1.8°	0° 36′ 00″	.999 957	.999 902	.010 471
1.9°	0° 38′ 00″	.999 952	.999 891	.011 053
2.0°	0° 40′ 00″	.999 947	.999 879	.011 635
2.1°	0° 42′ 00″	.999 941	.999 866	.012 216
2.2°	0° 44′ 00″	.999 935	.999 853	.012 798
2.3°	0° 46′ 00″	.999 929	.999 840	.013 379
2.4°	0° 48′ 00″	.999 923	.999 826	.013 961
2.5°	0° 50′ 00″	.999 916	.999 811	.014 542
2.6°	0° 52′ 00″	.999 910	.999 795	.015 124
2.7°	0° 54′ 00″	.999 903	.999 779	.015 706
2.8°	0° 56′ 00″	.999 895	.999 763	.016 287
2.9°	0° 58′ 00″	.999 888	.999 745	.016 868
3.0°	1° 00′ 00″	.999 880	.999 727	.017 450
3.1°	1° 02′ 00″	.999 872	.999 709	.018 031
3.2°	1° 04′ 00″	.999 863	.999 690	.018 613
3.3°	1° 06′ 00″	.999 854	.999 670	.019 194
3.4°	1° 08′ 00″	.999 846	.999 650	.019 775
3.5°	1° 10′ 00″	.999 836	.999 629	.020 357
3.6°	1° 12′ 00″	.999 827	.999 608	.020 938
3.7°	1° 14′ 00″	.999 817	.999 585	.021 519
3.8°	1° 16′ 00″	.999 807	.999 563	.022 101
3.9°	1° 18′ 00″	.999 797	.999 539	.022 682
4.0°	1° 20′ 00″	.999 786	.999 515	.023 263
4.1°	1° 22′ 00″	.999 775	.999 491	.023 844
4.2°	1° 24 00″	.999 764	999 466	.024 425
4.3°	1° 26′ 00″	.999 753	.999 440	.025 006
4.4°	1° 28′ 00″	.999 741	.999 414	.025 588
4.5°	1° 30′ 00″	.999 729	.999 387	.026 169
4.6°	1° 32′ 00″	.999 717	.999 359	.026 750
4.7°	1° 34′ 00″	.999 705	.999 331	.027 331
4.8°	1° 36′ 00″	.999 692	.999 302	.027 911
4.9°	1° 38′ 00″	.999 679	.999 273	.028 492
5.0°	1° 40′ 00″	.999 666	.999 243	029 073

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

U/L	V/L	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.666 667	.333 333	.000 000	.000 00	.500 000	.000 00	0.0°
.666 667	.333 333	.000 145	.000 00	.500 000	.000 13	0.1°
.666 667	.333 334	.000 291	.000 00	.500 000	.000 25	0.2°
.666 668	.333 334	.000 436	.000 00	.500 000	.000 38	0.3°
.666 668	.333 335	.000 582	.000 00	.499 999	.000 51	0.4°
.666 669	.333 336	.000 727	.000 00	.499 999	.000 64	0.5°
.666 671	.333 337	.000 873	.000 00	.499 998	.000 76	0.6°
.666 672	.333 338	.001 018	.000 01	.499 998	.000 89	0.7°
.666 674	.333 340	.001 164	.000 01	.499 997	.001 02	0.8°
.666 675	.333 341	.001 309	.000 01	.499 996	.001 15	0.9°
.666 677	.333 343	.001 454	.000 01	.499 995	.001 27	1.0°
.666 680	.333 345	.001 600	.000 01	.499 994	.001 40	1.1°
.666 682	.333 347	.001 745	.000 02	.499 993	.001 53	1.2°
.666 685	.333 350	.001 891	.000 02	.499 992	.001 66	1.3°
.666 688	.333 352	.002 036	.000 02	.499 990	.001 78	1.4°
.666 691	.333 355	.002 182	.000 03	.499 989	.001 91	1.5°
.666 694	.333 358	.002 327	.000 03	.499 987	.002 04	1.6°
.666 698	.333 362	.002 472	.000 03	.499 986	.002 17	1.7°
.666 701	.333 365	.002 618	.000 04	.499 984	.002 29	1.8°
.666 705	.333 369	.002 763	.000 04	.499 982	.002 42	1.9°
.666 710	.333 372	.002 909	.000 04	.499 980	.002 55	2.0°
.666 714	.333 376	.003 054	.000 05	.499 978	.002 68	2.1°
.666 719	.333 381	.003 200	.000 05	.499 976	.002 80	2.2°
.666 723	.333 385	.003 345	.000 06	.499 974	.002 93	2.3°
.666 728	.333 390	.003 490	.000 06	.499 972	.003 06	2.4°
.666 734	.333 394	.003 636	.000 07	.499 969	.003 18	2.5°
.666 739	.333 399	.003 781	.000 08	.499 967	.003 31	2.6°
.666 745	.333 405	.003 927	.000 08	.499 964	.003 44	2.7°
.666 751	.333 410	.004 072	.000 09	.499 962	.003 57	2.8°
.666 757	.333 415	.004 218	.000 09	.499 959	.003 69	2.9°
.666 763	.333 421	.004 363	.000 10	.499 956	.003 82	3.0°
.666 770	.333 427	.004 508	.000 11	.499 953	.003 95	3.1°
.666 776	.333 433	.004 654	.000 11	.499 950	.004 07	3.2°
.666 783	.333 440	.004 799	.000 12	.499 947	.004 20	3.3°
.666 791	.333 446	.004 945	.000 13	.499 943	.004 33	3.4°
.666 798	.333 453	.005 090	.000 14	.499 940	.004 46	3.5°
.666 806	.333 460	.005 235	.000 14	.499 936	.004 58	3.6°
.666 813	.333 467	.005 381	.000 15	.499 933	.004 71	3.7°
.666 822	.333 474	.005 526	.000 16	.499 929	.004 84	3.8°
.666 830	.333 482	.005 671	.000 17	.499 925	.004 97	3.9°
.666 838	.333 490	.005 817	.000 18	.499 922	.005 09	4.0°
.666 847	.333 498	.005 962	.000 19	.499 918	.005 22	4.1°
.666 856	.333 506	.006 108	.000 20	.499 914	.005 35	4.2°
.666 865	.333 514	.006 253	.000 21	.499 909	.005 47	4.3°
.666 874	.333 522	.006 398	.000 22	.499 905	.005 60	4.4°
.666 884	.333 531	.006 544	.000 23	.499 901	.005 73	4.5°
.666 894	.333 540	.006 689	.000 24	.499 896	.005 85	4.6°
.666 904	.333 549	.006 834	.000 25	.499 892	.005 98	4.7°
.666 914	.333 558	.006 980	.000 26	.499 887	.006 11	4.8°
.666 924	.333 568	.007 125	.000 27	.499 882	.006 24	4.9°
.666 935	.333 578	.007 270	.000 28	.499 877	.006 36	5.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
5.0°	1° 40′ 00″	.999 666	.999 243	.029 073
5.1°	1° 42′ 00″	.999 652	.999 212	.029 654
5.2°	1° 44′ 00″	.999 639	.999 181	.030 235
5.3°	1° 46′ 00″	.999 625	.999 150	.030 816
5.4°	1° 48′ 00″	.999 610	.999 117	.031 396
5.5°	1° 50′ 00″	.999 596	.999 084	.031 977
5.6°	1° 51′ 59″	.999 581	.999 051	.032 558
5.7°	1° 53′ 59″	.999 566	.999 016	.033 138
5.8°	1° 55′ 59″	.999 550	.998 982	.033 719
5.9°	1° 57′ 59″	.999 535	.998 946	.034 299
6.0°	1° 59′ 59″	.999 519	.998 910	.034 880
6.1°	2° 01′ 59″	.999 503	.998 874	.035 460
6.2°	2° 03′ 59″	.999 486	.998 836	.036 040
6.3°	2° 05′ 59″	.999 470	.998 799	.036 621
6.4°	2° 07′ 59″	.999 453	.998 760	.037 201
6.5°	2° 09′ 59″	.999 435	.998 721	.037 781
6.6°	2° 11′ 59″	.999 418	.998 681	.038 361
6.7°	2° 13′ 59″	.999 400	.998 641	.038 941
6.8°	2° 15′ 59″	.999 382	.998 600	.039 522
6.9°	2° 17′ 59″	.999 364	.998 559	.040 102
7.0°	2° 19′ 59″	.999 345	.998 517	.040 682
7.1°	2° 21′ 59″	.999 326	.998 474	.041 261
7.2°	2° 23′ 59″	.999 307	.998 431	.041 841
7.3°	2° 25′ 59″	.999 288	.998 387	.042 421
7.4°	2° 27′ 59″	.999 268	.998 343	.043 001
7.5°	2° 29′ 59″	.999 248	.998 298	.043 581
7.6°	2° 31′ 59″	.999 228	.998 252	.044 160
7.7°	2° 33′ 59″	.999 208	.998 206	.044 740
7.8°	2° 35′ 59″	.999 187	.998 159	.045 319
7.9°	2° 37′ 59″	.999 166	.998 111	.045 899
8.0°	2° 39′ 58″	.999 145	.998 063	.046 478
8.1°	2° 41′ 58″	.999 123	.998 015	.047 058
8.2°	2° 43′ 58″	.999 102	.997 965	.047 637
8.3°	2° 45′ 58″	.999 080	.997 915	.048 216
8.4°	2° 47′ 58″	.999 057	.997 865	.048 795
8.5°	2° 49′ 58″	.999 035	.997 814	.049 374
8.6°	2° 51′ 58″	.999 012	.997 762	.049 953
8.7°	2° 53′ 58″	.998 989	.997 710	.050 532
8.8°	2° 55′ 58″	.998 965	.997 657	.051 111
8.9°	2° 57′ 58″	.998 942	.997 603	.051 690
9.0°	2° 59′ 58″	.998 918	.997 549	.052 269
9.1°	3° 01′ 58″	.998 894	.997 495	.052 848
9.2°	3° 03′ 58″	.998 869	.997 439	.053 426
9.3°	3° 05′ 58	.998 844	.997 383	.054 005
9.4°	3° 07′ 58″	.998 819	.997 327	.054 583
9.5°	3° 09′ 57″	.998 794	.997 270	.055 162
9.6°	3° 11′ 57″	.998 769	.997 212	.055 740
9.7°	3° 13′ 57″	.998 743	.997 154	.056 318
9.8°	3° 15′ 57″	.998 717	.997 095	.056 897
9.9°	3° 17′ 57″	.998 691	.997 035	.057 475
10.0°	3° 19′ 57″	.998 664	.996 975	.058 053

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.666 935	.333 578	.007 270	.000 28	.499 877	.006 36	5.0°
.666 946	.333 587	.007 416	.000 29	.499 872	.006 49	5.1°
.666 957	.333 598	.007 561	.000 30	.499 867	.006 62	5.2°
.666 968	.333 608	.007 706	.000 31	.499 862	.006 74	5.3°
.666 979	.333 618	.007 852	.000 32	.499 857	.006 87	5.4°
.666 991	.333 629	.007 997	.000 34	.499 852	.007 00	5.5°
.667 003	.333 640	.008 142	.000 35	.499 846	.007 12	5.6°
.667 015	.333 651	.008 288	.000 36	.499 841	.007 25	5.7°
.667 028	.333 662	.008 433	.000 37	.499 835	.007 38	5.8°
.667 040	.333 674	.008 578	.000 39	.499 829	.007 50	5.9°
.667 053	.333 685	.008 724	.000 40	.499 824	.007 63	6.0°
.667 066	.333 697	.008 869	.000 41	.499 818	.007 76	6.1°
.667 079	.333 709	.009 014	.000 43	.499 812	.007 88	6.2°
.667 093	.333 721	.009 159	.000 44	.499 805	.008 01	6.3°
.667 106	.333 734	.009 305	.000 45	.499 799	.008 14	6.4°
.667 120	.333 746	.009 450	.000 47	.499 793	.008 26	6.5°
.667 134	.333 759	.009 595	.000 48	.499 786	.008 39	6.6°
.667 148	.333 772	.009 740	.000 50	.499 780	.008 52	6.7°
.667 163	.333 785	.009 886	.000 51	.499 773	.008 64	6.8°
.667 178	.333 799	.010 031	.000 53	.499 767	.008 77	6.9°
.667 193	.333 812	.010 176	.000 54	.499 760	.008 90	7.0°
.667 208	.333 826	.010 321	.000 56	.499 753	.009 02	7.1°
.667 223	.333 840	.010 467	.000 58	.499 746	.009 15	7.2°
.667 239	.333 854	.010 612	.000 59	.499 739	.009 28	7.3°
.667 255	.333 869	.010 757	.000 61	.499 732	.009 40	7.4°
.667 271	.333 883	.010 902	.000 62	.499 724	.009 53	7.5°
.667 287	.333 898	.011 048	.000 64	.499 717	.009 65	7.6°
.667 303	.333 913	.011 193	.000 66	.499 709	.009 78	7.7°
.667 320	.333 928	.011 338	.000 68	.499 702	.009 91	7.8°
.667 337	.333 944	.011 483	.000 69	.499 694	.010 03	7.9°
.667 354	.333 959	.011 628	.000 71	.499 686	.010 16	8.0°
.667 371	.333 975	.011 773	.000 73	.499 678	.010 29	8.1°
.667 389	.333 991	.011 919	.000 75	.499 670	.010 41	8.2°
.667 407	.334 007	.012 064	.000 76	.499 662	.010 54	8.3°
.667 424	.334 024	.012 209	.000 78	.499 654	.010 66	8.4°
.667 443	.334 040	.012 354	.000 80	.499 646	.010 79	8.5°
.667 461	.334 057	.012 499	.000 82	.499 637	.010 92	8.6°
.667 480	.334 074	.012 644	.000 84	.499 629	.011 04	8.7°
.667 499	.334 091	.012 789	.000 86	.499 620	.011 17	8.8°
.667 518	.334 109	.012 935	.000 88	.499 612	.011 29	8.9°
.667 537	.334 126	.013 080	.000 90	.499 603	.011 42	9.0°
.667 556	.334 144	.013 225	.000 92	.499 594	.011 55	9.1°
.667 576	.334 162	.013 370	.000 94	.499 585	.011 67	9.2°
.667 596	.334 180	.013 515	.000 96	.499 576	.011 80	9.3°
.667 616	.334 198	.013 660	.000 98	.499 567	.011 92	9.4°
.667 636	.334 217	.013 805	.001 00	.499 558	.012 05	9.5°
.667 657	.334 236	.013 950	.001 02	.499 548	.012 17	9.6°
.667 678	.334 255	.014 095	.001 04	.499 539	.012 30	9 7°
.667 699	.334 274	.014 240	.001 07	.499 529	.012 43	9.8°
.667 720	.334 293	.014 385	.001 09	.499 520	.012 55	9.9°
.667 742	.334 313	.014 530	.001 11	.499 510	.012 68	10.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	C/L	X/L	Y/L
10.0°	3° 19′ 57″	.998 664	.996 975	.058 053
10.1°	3° 21′ 57″	.998 637	.996 915	.058 631
10.2°	3° 23′ 57″	.998 610	.996 853	.059 209
10.3°	3° 25′ 57″	.998 583	.996 791	.059 787
10.4°	3° 27′ 57″	.998 555	.996 729	.060 364
10.5°	3° 29′ 57″	.998 527	.996 666	.060 942
10.6°	3° 31′ 56″	.998 499	.996 602	.061 520
10.7°	3° 33′ 56″	.998 471	.996 538	.062 097
10.8°	3° 35′ 56″	.998 442	.996 473	.062 675
10.9°	3° 37′ 56″	.998 413	.996 407	.063 252
11.0°	3° 39′ 56″	.998 384	.996 341	.063 829
11.1°	3° 41′ 56″	.998 354	.996 274	.064 406
11.2°	3° 43′ 56″	.998 324	.996 207	.064 984
11.3°	3° 45′ 56″	.998 294	.996 139	.065 561
11.4°	3° 47′ 56″	.998 264	.996 071	.066 138
11.5°	3° 49′ 55″	.998 233	.996 002	.066 714
11.6°	3° 51 55″	.998 203	.995 932	.067 291
11.7°	3° 53′ 55″	.998 171	.995 862	.067 868
11.8°	3° 55′ 55″	.998 140	.995 791	.068 445
11.9°	3° 57′ 55″	.998 108	.995 719	.069 021
12.0°	3° 59′ 55″	.998 077	.995 647	.069 598
12.1°	4° 01′ 55″	998 044	.995 574	.070 174
12.2°	4° 03′ 55″	.998 012	.995 501	.070 750
12.3°	4° 05′ 54″	.997 979	.995 427	.071 326
12.4°	4° 07′ 54″	.997 946	.995 353	.071 902
12.5°	4° 09′ 54″	.997 913	.995 278	.072 478
12.6°	4° 11′ 54″	.997 880	.995 202	.073 054
12.7°	4° 13′ 54″	.997 846	.995 126	.073 630
12.8°	4° 15′ 54″	.997 812	.995 049	.074 206
12.9°	4° 17′ 54″	.997 777	.994 971	.074 781
13.0°	4° 19′ 53″	.997 743	.994 893	.075 357
13.1°	4° 21′ 53″	.997 708	.994 814	.075 932
13.2°	4° 23′ 53″	.997 673	.994 735	.076 508
13.3°	4° 25′ 53″	.997 638	.994 655	.077 083
13.4°	4° 27′ 53″	.997 602	.994 575	.077 658
13.5°	4° 29′ 53″	.997 566	.994 494	.078 233
13.6°	4° 31′ 53″	.997 530	.994 412	.078 808
13.7°	4° 33′ 52″	.997 493	.994 330	.079 383
13.8°	4° 35′ 52″	.997 457	.994 247	.079 957
13.9°	4° 37′ 52	.997 420	.994 163	.080 532
14.0°	4° 39′ 52″	.997 383	.994 079	.081 106
14.1°	4° 41′ 52″	.997 345	.993 995	.081 681
14.2°	4° 43′ 51″	.997 307	.993 909	.082 255
14.3°	4° 45′ 51″	.997 269	.993 824	.082 829
14.4°	4° 47′ 51″	.997 231	.993 737	.083 403
14.5°	4° 49′ 51″	.997 192	.993 650	.083 977
14.6°	4° 51′ 51″	.997 154	.993 563	.084 551
14.7°	4° 53′ 51″	.997 115	.993 474	.085 125
14.8°	4° 55′ 50″	.997 075	.993 385	.085 699
14.9°	4° 57′ 50″	.997 036	.993 296	.086 272
15.0°	4° 59′ 50″	996 996	.993 206	.086 846

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.667 742	.334 313	.014 530	.001 11	.499 510	.012 68	10.0°
.667 763	.334 332	.014 675	.001 13	.499 500	.012 80	10.1°
.667 785	.334 352	.014 820	.001 15	.499 490	.012 93	10.2°
.667 807	.334 373	.014 965	.001 18	.499 480	.013 05	10.3°
.667 830	.334 393	.015 110	.001 20	.499 470	.013 18	10.4°
.667 852	.334 413	.015 255	.001 22	.499 460	.013 30	10.5°
.667 875	.334 434	.015 400	.001 25	.499 449	.013 43	10.6°
.667 898	.334 455	.015 545	.001 27	.499 439	.013 55	10.7°
.667 921	.334 476	.015 690	.001 29	.499 428	.013 68	10.8°
.667 944	.334 498	.015 835	.001 32	.499 418	.013 80	10.9°
.667 968	.334 519	.015 980	.001 34	.499 407	.013 93	11.0°
.667 992	.334 541	.016 125	.001 37	.499 396	.014 05	11.1°
.668 016	.334 563	.016 270	.001 39	.499 385	.014 18	11.2°
.668 040	.334 585	.016 415	.001 42	.499 374	.014 30	11.3°
.668 065	.334 607	.016 560	.001 44	.499 363	.014 43	11.4°
.668 089	.334 630	.016 704	.001 47	.499 352	.014 55	11.5°
.668 114	.334 653	.016 849	.001 49	.499 341	.014 68	11.6°
.668 140	.334 676	.016 994	.001 52	.499 329	.014 80	11.7°
.668 165	.334 699	.017 139	.001 54	.499 318	.014 93	11.8°
.668 191	.334 722	.017 284	.001 57	.499 306	.015 05	11.9°
.668 216	.334 746	.017 429	.001 60	.499 294	.015 18	12.0°
.668 242	.334 769	.017 574	.001 62	.499 283	.015 30	12.1°
.668 269	.334 793	.017 718	.001 65	.499 271	.015 43	12.2°
.668 295	.334 817	.017 863	.001 68	.499 259	.015 55	12.3°
.668 322	.334 842	.018 008	.001 70	.499 247	.015 68	12.4°
.668 349	.334 866	.018 153	.001 73	.499 234	.015 80	12.5°
.668 376	.334 891	.018 298	.001 76	.499 222	.015 92	12.6°
.668 403	.334 916	.018 442	.001 79	.499 210	.016 05	12.7°
.668 431	.334 941	.018 587	.001 81	.499 197	.016 17	12.8°
.668 459	.334 967	.018 732	.001 84	.499 185	.016 30	12.9°
.668 487	.334 992	.018 877	.001 87	.499 172	.016 42	13.0°
.668 515	.335 018	.019 021	.001 90	.499 159	.016 55	13.1°
.668 543	.335 044	.019 166	.001 93	.499 146	.016 67	13.2°
.668 572	.335 070	.019 311	.001 96	.499 133	.016 79	13.3°
.668 601	.335 096	.019 455	.001 99	.499 120	.016 92	13.4°
.668 630	.335 123	.019 600	.002 02	.499 107	.017 04	13.5°
.668 660	.335 150	.019 745	.002 05	.499 094	.017 17	13.6°
.668 689	.335 177	.019 889	.002 08	.499 081	.017 29	13.7°
.668 719	.335 204	.020 034	.002 11	.499 067	.017 41	13.8°
.668 749	.335 231	.020 179	.002 14	.499 054	.017 54	13.9°
.668 779	.335 259	.020 323	.002 17	.499 040	.017 66	14.0°
.668 810	.335 287	.020 468	.002 20	.499 026	.017 78	14.1°
.668 840	.335 315	.020 612	.002 23	.499 012	.017 91	14.2°
.668 871	.335 343	.020 757	.002 26	.498 998	.018 03	14.3°
.668 902	.335 371	.020 902	.002 29	.498 984	.018 15	14.4°
.668 934	.335 400	.021 046	.002 33	.498 970	.018 28	14.5°
.668 965	.335 429	.021 191	.002 36	.498 956	.018 40	14.6°
.668 997	.335 458	.021 335	.002 39	.498 942	.018 52	14.7°
.669 029	.335 487	.021 480	.002 42	.498 927	.018 65	14.8°
.669 061	.335 516	.021 624	.002 45	.498 913	.018 77	14.9°
.669 094	.335 546	.021 769	.002 49	.498 898	.018 89	15.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
15.0°	4° 59′ 50″	.996 996	.993 206	.086 846
15.1°	5° 01′ 50″	.996 956	.993 115	.087 419
15.2°	5° 03′ 50″	.996 915	.993 024	.087 992
15.3°	5° 05′ 49″	.996 874	.992 932	.088 565
15.4°	5° 07′ 49″	.996 833	.992 840	.089 138
15.5°	5° 09′ 49″	.996 792	.992 747	.089 711
15.6°	5° 11′ 49″	.996 751	.992 654	.090 284
15.7°	5° 13′ 49″	.996 709	.992 559	.090 856
15.8°	5° 15′ 48″	.996 667	.992 465	.091 429
15.9°	5° 17′ 48″	.996 625	.992 369	.092 001
16.0°	5° 19′ 48″	.996 582	.992 273	.092 574
16.1°	5° 21′ 48″	.996 539	.992 177	.093 146
16.2°	5° 23′ 47″	.996 496	.992 080	.093 718
16.3°	5° 25′ 47″	.996 453	.991 982	.094 290
16.4°	5° 27′ 47″	.996 409	.991 884	.094 862
16.5°	5° 29′ 47″	.996 366	.991 785	.095 433
16.6°	5° 31′ 46″	.996 321	.991 685	.096 005
16.7°	5° 33′ 46″	.996 277	.991 585	.096 576
16.8°	5° 35′ 46″	.996 232	.991 484	.097 148
16.9°	5° 37′ 46″	.996 187	.991 383	.097 719
17.0°	5° 39′ 45″	.996 142	.991 281	.098 290
17.1°	5° 41′ 45″	.996 097	.991 179	.098 861
17.2°	5° 43′ 45″	.996 051	.991 076	.099 432
17.3°	5° 45′ 45″	.996 005	.990 972	.100 002
17.4°	5° 47′ 44″	.995 959	.990 868	.100 573
17.5°	5° 49′ 44″	.995 912	.990 763	.101 143
17.6°	5° 51′ 44″	.995 865	.990 658	.101 713
17.7°	5° 53′ 44″	.995 818	.990 552	.102 284
17.8°	5° 55′ 43″	.995 771	.990 445	.102 854
17.9°	5° 57′ 43″	.995 723	.990 338	.103 424
18.0°	5° 59′ 43″	.995 676	.990 230	.103 993
18.1°	6° 01′ 42″	.995 628	.990 122	.104 563
18.2°	6° 03′ 42″	.995 579	.990 013	.105 132
18.3°	6° 05′ 42″	.995 530	.989 903	.105 702
18.4°	6° 07′ 42″	.995 482	.989 793	.106 271
18.5°	6° 09 41″	.995 432	.989 682	.106 840
18.6°	6° 11′ 41″	.995 383	.989 571	107 409
18.7°	6° 13′ 41″	.995 333	.989 459	.107 978
18.8°	6° 15′ 40″	.995 283	.989 347	.108 547
18.9°	6° 17′ 40″	.995 233	.989 233	.109 115
19.0°	6° 19′ 40″	.995 183	.989 120	.109 683
19.1°	6° 21′ 39″	.995 132	.989 005	.110 252
19.2°	6° 23′ 39″	.995 081	.988 891	.110 820
19.3°	6° 25′ 39″	.995 029	.988 775	.111 388
19.4°	6° 27′ 38″	.994 978	.988 659	.111 956
19.5°	6° 29′ 38″	.994 926	.988 543	.112 523
19.6°	6° 31′ 38″	.994 874	.988 425	.113 091
19.7°	6° 33′ 37″	.994 822	.988 308	.113 658
19.8°	6° 35′ 37″	.994 769	.988 189	.114 225
19.9°	6° 37′ 37″	.994 716	.988 070	.114 793
20.0°	6° 39′ 36″	.994 663	.987 951	.115 360

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.669 094	.335 546	.021 769	.002 49	.498 898	.018 89	15.0°
.669 126	.335 576	.021 913	.002 52	.498 883	.019 02	15.1°
.669 159	.335 606	.022 058	.002 55	.498 869	.019 14	15.2°
.669 192	.335 636	.022 202	.002 59	.498 854	.019 26	15.3°
.669 226	.335 666	.022 347	.002 62	.498 839	.019 39	15.4°
.669 259	.335 697	.022 491	.002 65	.498 824	.019 51	15.5°
.669 293	.335 728	.022 635	.002 69	.498 808	.019 63	15.6°
.669 327	.335 759	.022 780	.002 72	.498 793	.019 75	15.7°
.669 361	.335 790	.022 924	.002 76	.498 778	.019 88	15.8°
.669 396	.335 821	.023 069	.002 79	.498 762	.020 00	15.9°
.669 431	.335 853	.023 213	.002 83	.498 747	.020 12	16.0°
.669 465	.335 885	.023 357	.002 86	.498 731	.020 24	16.1°
.669 501	.335 917	.023 502	.002 90	.498 715	.020 37	16.2°
.669 536	.335 949	.023 646	.002 93	.498 699	.020 49	16.3°
.669 572	.335 982	.023 790	.002 97	.498 683	.020 61	16.4°
.669 607	.336 014	.023 935	.003 01	.498 667	.020 73	16.5°
.669 643	.336 047	.024 079	.003 04	.498 651	.020 86	16.6°
.669 680	.336 080	.024 223	.003 08	.498 635	.020 98	16.7°
.669 716	.336 114	.024 367	.003 12	.498 618	.021 10	16.8°
.669 753	.336 147	.024 512	.003 15	.498 602	.021 22	16.9°
.669 790	.336 181	.024 656	.003 19	.498 585	.021 34	17.0°
.669 827	.336 215	.024 800	.003 23	.498 569	.021 46	17.1°
.669 864	.336 249	.024 944	.003 26	.498 552	.021 59	17.2°
.669 902	.336 283	.025 088	.003 30	.498 535	.021 71	17.3°
.669 940	.336 318	.025 233	.003 34	.498 518	.021 83	17.4°
.669 978	.336 353	.025 377	.003 38	.498 501	.021 95	17.5°
.670 016	.336 388	.025 521	.003 42	.498 484	.022 07	17.6°
.670 055	.336 423	.025 665	.003 46	.498 466	.022 19	17.7°
.670 093	.336 458	.025 809	.003 49	.498 449	.022 32	17.8°
.670 132	.336 494	.025 953	.003 53	.498 432	.022 44	17.9°
.670 172	.336 529	.026 097	.003 57	.498 414	.022 56	18.0°
.670 211	.336 565	.026 241	.003 61	.498 397	.022 68	18.1°
.670 251	.336 602	.026 385	.003 65	.498 379	.022 80	18.2°
.670 290	.336 638	.026 529	.003 69	.498 361	.022 92	18.3°
.670 331	.336 675	.026 673	.003 73	.498 343	.023 04	18.4°
.670 371	.336 711	.026 817	.003 77	.498 325	.023 16	18.5°
.670 411	.336 748	.026 961	.003 81	.498 307	.023 28	18.6°
.670 452	.336 786	.027 105	.003 85	.498 289	.023 40	18.7°
.670 493	.336 823	.027 249	.003 89	.498 270	.023 53	18.8°
.670 534	.336 861	.027 393	.003 94	.498 252	.023 65	18.9°
.670 576	.336 899	.027 537	.003 98	.498 233	.023 77	19.0°
.670 618	.336 937	.027 681	.004 02	.498 215	.023 89	19.1°
.670 660	.336 975	.027 825	.004 06	.498 196	.024 01	19.2°
.670 702	.337 013	.027 969	.004 10	.498 177	.024 13	19.3°
.670 744	.337 052	.028 113	.004 14	.498 158	.024 25	19.4°
.670 787	.337 091	.028 257	.004 19	.498 139	.024 37	19.5°
.670 829	.337 130	.028 400	.004 23	.498 120	.024 49	19.6°
.670 873	.337 169	.028 544	.004 27	.498 101	.024 61	19.7°
.670 916	.337 209	.028 688	.004 32	.498 082	.024 73	19.8°
.670 959	.337 249	.028 832	.004 36	.498 062	.024 85	19.9°
.671 003	.337 289	.028 976	.004 40	.498 043	.024 97	20.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
20.0°	6° 39′ 36″	.994 663	.987 951	.115 360
20.1°	6° 41′ 36″	.994 610	.987 831	.115 926
20.2°	6° 43 36°	.994 556	.987 710	.116 493
20.3°	6° 45′ 35″	.994 502	.987 589	.117 060
20.4°	6° 47′ 35″	.994 448	.987 467	.117 626
20.5°	6° 49′ 34″	.994 393	.987 344	.118 192
20.6°	6° 51′ 34″	.994 339	.987 221	.118 758
20.7°	6° 53′ 34″	.994 284	.987 098	.119 324
20.8°	6° 55′ 33″	.994 228	.986 973	.119 890
20.9°	6° 57′ 33″	.994 173	.986 849	.120 455
21.0°	6° 59′ 32″	.994 117	.986 723	.121 021
21.1°	7° 01′ 32″	.994 061	.986 597	.121 586
21.2°	7° 03′ 32″	.994 005	.986 471	.122 151
21.3°	7° 05′ 31″	.993 948	.986 343	.122 716
21.4°	7° 07′ 31″	.993 891	.986 216	.123 281
21.5°	7° 09′ 30″	.993 834	.986 087	.123 846
21.6°	7° 11′ 30″	.993 777	.985 959	.124 410
21.7°	7° 13′ 30″	.993 719	.985 829	.124 975
21.8°	7° 15′ 29″	.993 661	.985 699	.125 539
21.9°	7° 17′ 29″	.993 603	.985 568	.126 103
22.0°	7° 19′ 28″	.993 545	.985 437	.126 667
22.1°	7° 21′ 28″	.993 486	.985 305	.127 230
22.2°	7° 23′ 28″	.993 427	.985 173	.127 794
22.3°	7° 25′ 27″	.993 368	.985 040	.128 357
22.4°	7° 27′ 27″	.993 308	.984 906	.128 920
22.5°	7° 29′ 26″	.993 248	.984 772	.129 483
22.6°	7° 31′ 26″	993 188	.984 638	.130 046
22.7°	7° 33′ 25″	.993 128	.984 502	.130 609
22.8°	7° 35′ 25″	.993 068	.984 366	.131 172
22.9°	7° 37′ 24″	.993 007	.984 230	.131 734
23.0°	7° 39′ 24″	.992 946	.984 093	.132 296
23.1°	7° 41′ 23″	.992 884	.983 955	.132 858
23.2°	7° 43′ 23″	.992 823	.983 817	.133 420
23.3°	7° 45′ 22″	.992 761	.983 678	.133 982
23.4°	7° 47′ 22″	.992 699	.983 539	.134 543
23.5°	7° 49′ 21″	.992 636	.983 399	.135 105
23.6°	7° 51′ 21″	.992 574	.983 259	.135 666
23.7°	7° 53′ 20″	.992 511	.983 118	.136 227
23.8°	7° 55′ 20″	.992 448	.982 976	.136 788
23.9°	7° 57′ 19″	.992 384	.982 834	.137 348
24.0°	7° 59′ 19″	.992 321	.982 691	.137 909
24.1°	8° 01′ 18″	.992 257	.982 547	.138 469
24.2°	8° 03′ 18″	.992 192	.982 403	.139 029
24.3°	8° 05′ 17″	.992 128	.982 259	.139 589
24.4°	8° 07′ 17″	.992 063	.982 114	.140 149
24.5°	8° 09′ 16″	.991 998	.981 968	.140 708
24.6°	8° 11′ 16″	.991 933	.981 822	.141 268
24.7°	8° 13′ 15″	.991 867	.981 675	.141 827
24.8°	8° 15′ 15″	.991 801	.981 528	.142 386
24.9°	8° 17′ 14″	.991 735	.981 380	.142 945
25.0°	8° 19′ 14″	.991 669	.981 231	.143 504

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.671 003	.337 289	.028 976	.004 40	.498 043	.024 97	20.0°
.671 047	.337 329	.029 119	.004 45	.498 023	.025 09	20.1°
.671 091	.337 369	.029 263	.004 49	.498 004	.025 21	20.2°
.671 136	.337 410	.029 407	.004 53	.497 984	.025 33	20.3°
.671 180	.337 451	.029 550	.004 58	.497 964	.025 45	20.4°
.671 225	.337 492	.029 694	.004 62	.497 944	.025 57	20.5°
.671 270	.337 533	.029 838	.004 67	.497 924	.025 68	20.6°
.671 316	.337 574	.029 981	.004 71	.497 904	.025 80	20.7°
.671 361	.337 616	.030 125	.004 76	.497 884	.025 92	20.8°
.671 407	.337 658	.030 269	.004 80	.497 863	.026 04	20.9°
.671 453	.337 700	.030 412	.004 85	.497 843	.026 16	21.0°
.671 499	.337 742	.030 556	.004 89	.497 822	.026 28	21.1°
.671 546	.337 785	.030 699	.004 94	.497 802	.026 40	21.2°
.671 593	.337 827	.030 843	.004 99	.497 781	.026 52	21.3°
.671 640	.337 870	.030 986	.005 03	.497 760	.026 64	21.4°
.671 687	.337 913	.031 130	.005 08	.497 739	.026 75	21.5°
.671 734	.337 957	.031 273	.005 13	.497 718	.026 87	21.6°
.671 782	.338 000	.031 417	.005 17	.497 697	.026 99	21.7°
.671 830	.338 044	.031 560	.005 22	.497 676	.027 11	21.8°
.671 878	.338 088	.031 704	.005 27	.497 655	.027 23	21.9°
.671 926	.338 132	.031 847	.005 32	.497 633	.027 35	22.0°
.671 975	.338 177	.031 990	.005 36	.497 612	.027 46	22.1°
.672 024	.338 221	.032 134	.005 41	.497 590	.027 58	22.2°
.672 073	.338 266	.032 277	.005 46	.497 568	.027 70	22.3°
.672 122	.338 311	.032 421	.005 51	.497 547	.027 82	22.4°
.672 172	.338 356	.032 564	.005 56	.497 525	.027 94	22.5°
.672 221	.338 402	.032 707	.005 61	.497 503	.028 05	22.6°
.672 271	.338 448	.032 850	.005 65	.497 481	.028 17	22.7°
.672 322	.338 494	.032 994	.005 70	.497 458	.028 29	22.8°
.672 372	.338 540	.033 137	.005 75	.497 436	.028 41	22.9°
.672 423	.338 586	.033 280	.005 80	.497 414	.028 52	23.0°
.672 474	.338 633	.033 423	.005 85	.497 391	.028 64	23.1°
.672 525	.338 679	.033 567	.005 90	.497 369	.028 76	23.2°
.672 576	.338 726	.033 710	.005 95	.497 346	.028 87	23.3°
.672 628	.338 774	.033 853	.006 00	.497 323	.028 99	23.4°
.672 680	.338 821	.033 996	.006 05	.497 300	.029 11	23.5°
.672 732	.338 869	.034 139	.006 11	.497 277	.029 23	23.6°
.672 784	.338 917	.034 282	.006 16	.497 254	.029 34	23.7°
.672 837	.338 965	.034 425	.006 21	.497 231	.029 46	23.8°
.672 890	.339 013	.034 568	.006 26	.497 208	.029 58	23.9°
.672 943	.339 061	.034 711	.006 31	.497 185	.029 69	24.0°
.672 996	.339 110	.034 854	.006 36	.497 161	.029 81	24.1°
.673 050	.339 159	.034 997	.006 42	.497 138	.029 92	24.2°
.673 103	.339 208	.035 140	.006 47	.497 114	.030 04	24.3°
.673 157	.339 258	.035 283	.006 52	.497 090	.030 16	24.4°
.673 212	.339 307	.035 426	.006 57	.497 067	.030 27	24.5°
.673 266	.339 357	.035 569	.006 63	.497 043	.030 39	24.6°
.673 321	.339 407	.035 712	.006 68	.497 019	.030 50	24.7°
.673 376	.339 457	.035 855	.006 73	.496 995	.030 62	24.8°
.673 431	.339 508	.035 998	.006 79	.496 970	.030 74	24.9°
.673 486	.339 559	.036 140	.006 84	.496 946	.030 85	25.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
25.0°	8° 19′ 14″	.991 669	.981 231	.143 504
25.1°	8° 21′ 13″	.991 602	.981 082	.144 062
25.2°	8° 23′ 12″	.991 536	.980 932	.144 620
25.3°	8° 25′ 12″	.991 468	.980 782	.145 179
25.4°	8° 27′ 11″	.991 401	.980 631	.145 737
25.5°	8° 29′ 11″	.991 333	.980 479	.146 294
25.6°	8° 31′ 10″	.991 266	.980 327	.146 852
25.7°	8° 33′ 10″	.991 197	.980 175	.147 409
25.8°	8° 35′ 09″	.991 129	.980 022	.147 966
25.9°	8° 37′ 08″	.991 060	.979 868	.148 523
26.0°	8° 39′ 08″	.990 991	.979 714	.149 080
26.1°	8° 41′ 07″	.990 922	.979 559	.149 637
26.2°	8° 43′ 07″	.990 853	.979 403	.150 193
26.3°	8° 45′ 06″	.990 783	.979 247	.150 750
26.4°	8° 47′ 05″	.990 713	.979 091	.151 306
26.5°	8° 49′ 05″	.990 642	.978 933	.151 861
26.6°	8° 51′ 04″	.990 572	.978 776	.152 417
26.7°	8° 53′ 03″	.990 501	.978 617	.152 973
26.8°	8° 55′ 03″	.990 430	.978 458	.153 528
26.9°	8° 57′ 02″	.990 359	.978 299	.154 083
27.0°	8° 59′ 02″	.990 287	.978 139	.154 638
27.1°	9° 01′ 01″	.990 215	.977 978	.155 193
27.2°	9° 03′ 00″	.990 143	.977 817	.155 747
27.3°	9° 05′ 00″	.990 071	.977 655	.156 301
27.4°	9° 06′ 59″	.989 998	.977 493	.156 855
27.5°	9° 08′ 58″	.989 925	.977 330	.157 409
27.6°	9° 10′ 58″	.989 852	.977 167	.157 963
27.7°	9° 12′ 57″	.989 779	.977 003	.158 516
27.8°	9° 14′ 56″	.989 705	.976 838	.159 070
27.9°	9° 16′ 55″	.989 631	.976 673	.159 623
28.0°	9° 18′ 55″	.989 557	.976 507	.160 176
28.1°	9° 20′ 54″	.989 482	.976 341	.160 728
28.2°	9° 22′ 53″	.989 408	.976 174	.161 281
28.3°	9° 24′ 53″	.989 333	.976 007	.161 833
28.4°	9° 26′ 52″	.989 257	.975 839	.162 385
28.5°	9° 28′ 51″	.989 182	.975 670	.162 937
28.6°	9° 30′ 51″	.989 106	.975 501	.163 489
28.7°	9° 32′ 50″	.989 030	.975 331	.164 040
28.8°	9° 34′ 49″	.988 954	.975 161	.164 591
28.9°	9° 36′ 48″	.988 877	.974 990	.165 142
29.0°	9° 38′ 48″	.988 800	.974 819	.165 693
29.1°	9° 40′ 47″	.988 723	.974 647	.166 244
29.2°	9° 42′ 46″	.988 646	.974 475	.166 794
29.3°	9° 44′ 45″	.988 568	.974 302	.167 344
29.4°	9° 46′ 45″	.988 491	.974 128	.167 894
29.5°	9° 48′ 44″	.988 412	.973 954	.168 444
29.6°	9° 50′ 43″	.988 334	.973 779	.168 993
29.7°	9° 52′ 42″	.988 255	.973 604	.169 543
29.8°	9° 54′ 41″	.988 177	.973 428	.170 092
29.9°	9° 56′ 41″	.988 097	.973 251	.170 641
30.0°	9° 58′ 40″	988 018	.973 074	.171 189

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.673 486	.339 559	.036 140	.006 84	.496 946	.030 85	25.0°
.673 542	.339 610	.036 283	.006 89	.496 922	.030 97	25.1°
.673 598	.339 661	.036 426	.006 95	.496 897	.031 08	25.2°
.673 654	.339 712	.036 569	.007 00	.496 873	.031 20	25.3°
.673 710	.339 764	.036 711	.007 06	.496 848	.031 31	25.4°
.673 767	.339 815	.036 854	.007 11	.496 823	.031 43	25.5°
.673 824	.339 867	.036 997	.007 17	.496 798	.031 54	25.6°
.673 881	.339 920	.037 139	.007 22	.496 773	.031 66	25.7°
.673 938	.339 972	.037 282	.007 28	.496 748	.031 77	25.8°
.673 996	.340 025	.037 425	.007 33	.496 723	.031 89	25.9°
.674 054	.340 078	.037 567	.007 39	.496 698	.032 00	26.0°
.674 112	.340 131	.037 710	.007 44	.496 673	.032 12	26.1°
.674 170	.340 184	.037 852	.007 50	.496 647	.032 23	26.2°
.674 229	.340 238	.037 995	.007 56	.496 622	.032 34	26.3°
.674 287	.340 292	.038 138	.007 61	.496 596	.032 46	26.4°
.674 346	.340 346	.038 280	.007 67	.496 570	.032 57	26.5°
.674 406	.340 400	.038 422	.007 73	.496 544	.032 69	26.6°
.674 465	.340 454	.038 565	.007 78	.496 518	.032 80	26.7°
.674 525	.340 509	.038 707	.007 84	.496 492	.032 91	26.8°
.674 585	.340 564	.038 850	.007 90	.496 466	.033 03	26.9°
.674 645	.340 619	.038 992	.007 96	.496 440	.033 14	27.0°
.674 706	.340 674	.039 135	.008 01	.496 414	.033 25	27.1°
.674 766	.340 730	.039 277	.008 07	.496 387	.033 37	27.2°
.674 827	.340 786	.039 419	.008 13	.496 361	.033 48	27.3°
.674 888	.340 842	.039 561	.008 19	.496 334	.033 59	27.4°
.674 950	.340 898	.039 704	.008 25	.496 308	.033 71	27.5°
.675 012	.340 955	.039 846	.008 31	.496 281	.033 82	27.6°
.675 074	.341 011	.039 988	.008 37	.496 254	.033 93	27.7°
.675 136	.341 068	.040 130	.008 43	.496 227	.034 05	27.8°
.675 198	.341 125	.040 273	.008 49	.496 200	.034 16	27.9°
.675 261	.341 183	.040 415	.008 54	.496 173	.034 27	28.0°
.675.324	.341 240	.040 557	.008 60	.496 145	.034 38	28.1°
.675 387	.341 298	.040 699	.008 66	.496 118	.034 50	28.2°
.675 450	.341 356	.040 841	.008 73	.496 091	.034 61	28.3°
.675 514	.341 415	.040 983	.008 79	.496 063	.034 72	28.4°
.675 578	.341 473	.041 125	.008 85	.496 036	.034 83	28.5°
.675 642	.341 532	.041 267	.008 91	.496 008	.034 94	28.6°
.675 706	.341 591	.041 409	.008 97	.495 980	.035 06	28.7°
.675 771	.341 650	.041 551	.009 03	.495 952	.035 17	28.8°
.675 836	.341 710	.041 693	.009 09	.495 924	.035 28	28.9°
.675 901	.341 769	.041 835	.009 15	.495 896	.035 39	29.0°
.675 966	.341 829	.041 977	.009 21	.495 868	.035 50	29.1°
.676 032	.341 889	.042 119	.009 28	.495 839	.035 61	29.2°
.676 098	.341 950	.042 261	.009 34	.495 811	.035 72	29.3°
.676 164	.342 010	.042 402	.009 40	.495 782	.035 84	29.4°
.676 230	.342 071	.042 544	.009 46	.495 754	.035 95	29.5°
.676 297	.342 132	.042 686	.009 53	.495 725	.036 06	29.6°
.676 364	.342 193	.042 828	.009 59	.495 696	.036 17	29.7°
.676 431	.342 255	.042 970	.009 65	.495 668	.036 28	29.8°
.676 498	.342 316	.043 111	.009 72	.495 639	.036 39	29.9°
.676 566	.342 378	.043 253	.009 78	.495 610	.036 50	30.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
30.0°	9° 58′ 40″	.988 018	.973 074	.171 189
30.1°	10° 00′ 39″	.987 938	.972 897	.171 738
30.2°	10° 02′ 38″	.987 858	.972 719	.172 286
30.3°	10° 04′ 37″	.987 778	.972 540	.172 834
30.4°	10° 06′ 37″	.987 698	.972 361	.173 382
30.5°	10° 08′ 36″	.987 617	.972 181	.173 929
30.6°	10° 10′ 35″	.987 536	.972 000	.174 477
30.7°	10° 12′ 34″	.987 455	.971 820	.175 024
30.8°	10° 14′ 33″	.987 373	.971 638	.175 571
30.9°	10° 16′ 32″	.987 291	.971 456	.176 117
31.0°	10° 18′ 32″	.987 209	.971 273	.176 664
31.1°	10° 20′ 31″	.987 127	.971 090	.177 210
31.2°	10° 22′ 30″	.987 044	.970 907	.177 756
31.3°	10° 24′ 29″	.986 962	.970 722	.178 302
31.4°	10° 26′ 28″	.986 879	.970 537	.178 847
31.5°	10° 28′ 27″	.986 795	.970 352	.179 392
31.6°	10° 30′ 26″	.986 712	.970 166	.179 938
31.7°	10° 32′ 25″	.986 628	.969 980	.180 482
31.8°	10° 34′ 24″	.986 544	.969 792	.181 027
31.9°	10° 36′ 24″	.986 459	.969 605	.181 571
32.0°	10° 38′ 23″	.986 375	.969 417	.182 116
32.1°	10° 40′ 22″	.986 290	.969 228	.182 659
32.2°	10° 42′ 21″	.986 205	.969 039	.183 203
32.3°	10° 44′ 20″	.986 119	.968 849	.183 747
32.4°	10° 46′ 19″	.986 033	.968 658	.184 290
32.5°	10° 48′ 18″	.985 948	.968 467	.184 833
32.6°	10° 50′ 17″	.985 861	.968 276	.185 376
32.7°	10° 52′ 16″	.985 775	.968 084	.185 918
32.8°	10° 54′ 15″	.985 688	.967 891	.186 460
32.9°	10° 56′ 14″	.985 601	.967 698	.187 002
33.0°	10° 58′ 13″	.985 514	.967 504	.187 544
33.1°	11° 00′ 12″	.985 426	.967 310	.188 086
33.2°	11° 02′ 11″	.985 339	.967 115	.188 627
33.3°	11° 04′ 10″	.985 251	.966 920	.189 168
33.4°	11° 06′ 09″	.985 162	.966 724	.189 709
33.5°	11° 08′ 08″	.985 074	.966 528	.190 250
33.6°	11° 10′ 07″	.984 985	.966 331	.190 790
33.7°	11° 12′ 06″	.984 896	.966 133	.191 330
33.8°	11° 14′ 05″	.984 807	.965 935	.191 870
33.9°	11° 16′ 04″	.984 717	.965 736	.192 410
34.0°	11° 18′ 03″	.984 627	.965 537	.192 949
34.1°	11° 20′ 02″	.984 537	.965 337	.193 488
34.2°	11° 22′ 01″	.984 447	.965 137	.194 027
34.3°	11° 24′ 00″	.984 356	.964 936	.194 566
34.4°	11° 25′ 59″	.984 265	.964 735	.195 104
34.5°	11° 27′ 58″	.984 174	.964 533	.195 643
34.6°	11° 29′ 57″	.984 083	.964 330	.196 180
34.7°	11° 31′ 56″	.983 991	.964 127	.196 718
34.8°	11° 33′ 55″	.983 899	.963 923	.197 256
34.9°	11° 35′ 54″	.983 807	.963 719	.197 793
35.0°	11° 37′ 53″	.983 715	.963 515	.198 330

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.676 566	.342 378	.043 253	.009 78	.495 610	.036 50	30.0°
.676 634	.342 441	.043 395	.009 84	.495 580	.036 61	30.1°
.676 702	.342 503	.043 536	.009 91	.495 551	.036 72	30.2°
.676 770	.342 566	.043 678	.009 97	.495 522	.036 83	30.3°
.676 839	.342 629	.043 819	.010 04	.495 492	.036 94	30.4°
.676 908	.342 692	.043 961	.010 10	.495 463	.037 05	30.5°
.676 977	.342 755	.044 102	.010 17	.495 433	.037 16	30.6°
.677 046	.342 819	.044 244	.010 23	.495 403	.037 27	30.7°
.677 116	.342 882	.044 385	.010 30	.495 374	.037 38	30.8°
.677 186	.342 947	.044 527	.010 36	.495 344	.037 49	30.9°
.677 256	.343 011	.044 668	.010 43	.495 314	.037 60	31.0°
.677 326	.343 075	.044 810	.010 49	.495 284	.037 71	31.1°
.677 397	.343 140	.044 951	.010 56	.495 253	.037 82	31.2°
.677 468	.343 205	.045 092	.010 62	.495 223	.037 92	31.3°
677 539	.343 270	.045 234	.010 69	.495 193	.038 03	31.4°
.677 610	.343 336	.045 375	.010 76	.495 162	.038 14	31.5°
.677 682	.343 401	.045 516	.010 82	.495 132	.038 25	31.6°
.677 754	.343 467	.045 658	.010 89	.495 101	.038 36	31.7°
.677 826	.343 534	.045 799	.010 96	.495 070	.038 47	31.8°
.677 898	.343 600	.045 940	.011 03	.495 039	.038 58	31.9°
.677 971	.343 667	.046 081	.011 09	.495 008	.038 68	32.0°
.678 044	.343 733	.046 222	.011 16	.494 977	.038 79	32.1°
.678 117	.343 801	046 363	.011 23	.494 946	.038 90	32.2°
.678 190	.343 868	046 504	.011 30	.494 915	.039 01	32.3°
.678 264	.343 936	.046 646	.011 36	.494 884	.039 12	32.4°
.678 338	.344 003	.046 787	.011 43	.494 852	.039 22	32.5°
.678 412	.344 071	.046 928	.011 50	.494 821	.039 33	32.6°
678 487	.344 140	.047 069	.011 57	.494 789	.039 44	32.7°
678 561	.344 208	.047 210	.011 64	.494 757	.039 54	32.8°
.678 636	.344 277	.047 350	.011 71	.494 725	.039 65	32.9°
.678 712	.344 346	.047 491	.011 78	.494 694	.039 76	33.0°
678 787	.344 415	.047 632	.011 85	.494 662	.039 87	33.1°
678 863	.344 485	.047 773	.011 92	.494 629	.039 97	33.2°
678 939	.344 555	.047 914	.011 99	.494 597	.040 08	33.3°
.679 015	.344 625	.048 055	.012 06	.494 565	.040 19	33.4°
679 092	.344 695	.048 195	.012 13	.494 533	.040 29	33.5°
.679 168	.344 765	.048 336	.012 20	.494 500	.040 40	33.6°
.679 245	.344 836	048 477	.012 27	.494 468	.040 50	33.7°
.679 323	.344 907	.048 618	.012 34	.494 435	.040 61	33.8°
.679 400	.344 978	.048 758	.012 41	.494 402	.040 72	33.9°
.679 478	.345 049	.048 899	.012 48	.494 369	.040 82	34.0°
.679 556	.345 121	.049 039	.012 55	.494 336	.040 93	34.1°
.679 634	.345 193	.049 180	.012 62	.494 303	.041 03	34.2°
.679 713	.345 265	.049 321	.012 69	.494 270	.041 14	34.3°
.679 792	.345 338	.049 461	.012 77	.494 237	.041 24	34.4°
.679 871	.345 410	.049 602	.012 84	.494 204	.041 35	34.5°
.679 950	.345 483	.049 742	.012 91	.494 170	.041 45	34.6°
.680 030	.345 556	.049 882	.012 98	.494 137	.041 56	34.7°
.680 110	.345 630	.050 023	.013 06	.494 103	.041 66	34.8°
.680 190	.345 703	.050 163	.013 13	.494 070	.041 77	34.9°
.680 270	.345 777	.050 304	.013 20	.494 036	.041 87	35.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
35.0°	11° 37′ 53″	.983 715	.963 515	.198 330
35.1°	11° 39′ 52″	.983 622	.963 309	.198 866
35.2°	11° 41′ 50″	.983 529	.963 103	.199 403
35.3°	11° 43′ 49″	.983 436	.962 897	.199 939
35.4°	11° 45′ 48″	.983 343	.962 690	.200 475
35.5°	11° 47′ 47″	.983 249	.962 483	.201 010
35.6°	11° 49′ 46″	.983 155	.962 275	.201 546
35.7°	11° 51′ 45″	.983 061	.962 066	.202 081
35.8°	11° 53′ 44″	.982 966	.961 857	.202 616
35.9°	11° 55′ 43″	.982 872	.961 648	.203 151
36.0°	11° 57′ 41″	.982 777	.961 438	.203 685
36.1°	11° 59′ 40″	.982 681	.961 227	.204 219
36.2°	12° 01′ 39″	.982 586	.961 016	.204 753
36.3°	12° 03′ 38″	.982 490	.960 804	.205 286
36.4°	12° 05′ 37″	.982 394	.960 592	.205 820
36.5°	12° 07′ 36″	.982 298	.960 379	.206 353
36.6°	12° 09′ 34″	.982 201	.960 165	.206 886
36.7°	12° 11′ 33″	.982 104	.959 951	.207 418
36.8°	12° 13′ 32″	.982 007	.959 737	.207 951
36.9°	12° 15′ 31″	.981 910	.959 522	.208 483
37.0°	12° 17′ 30″	.981 812	.959 306	.209 014
37.1°	12° 19′ 28″	.981 715	.959 090	.209 546
37.2°	12° 21′ 27″	.981 617	.958 874	.210 077
37.3°	12° 23′ 26″	.981 518	.958 657	.210 608
37.4°	12° 25′ 25″	.981 420	.958 439	.211 139
37.5°	12° 27′ 23″	.981 321	.958 221	.211 669
37.6°	12° 29′ 22″	.981 222	.958 002	.212 199
37.7°	12° 31′ 21″	.981 122	.957 783	.212 729
37.8°	12° 33′ 20″	.981 023	.957 563	.213 259
37.9°	12° 35′ 18″	.980 923	.957 342	.213 788
38.0°	12° 37′ 17″	.980 823	.957 121	.214 317
38.1°	12° 39′ 16″	.980 722	.956 900	.214 846
38.2°	12° 41′ 14″	.980 622	.956 678	.215 375
38.3°	12° 43′ 13″	.980 521	.956 455	.215 903
38.4°	12° 45′ 12″	.980 420	.956 232	.216 431
38.5°	12° 47′ 11″	.980 318	.956 009	.216 959
38.6°	12° 49′ 09″	.980 217	.955 785	.217 486
38.7°	12° 51′ 08″	.980 115	.955 560	.218 013
38.8°	12° 53′ 07″	.980 012	.955 335	.218 540
38.9°	12° 55′ 05″	.979 910	.955 109	.219 067
39.0°	12° 57′ 04″	.979 807	.954 883	.219 593
39.1°	12° 59′ 02″	.979 704	.954 656	.220 119
39.2°	13° 01′ 01″	.979 601	.954 429	.220 645
39.3°	13° 03′ 00″	.979 498	.954 201	.221 171
39.4°	13° 04′ 58″	.979 394	.953 973	.221 696
39.5°	13° 06′ 57″	.979 290	.953 744	.222 221
39.6°	13° 08′ 56″	.979 186	.953 514	.222 745
39.7°	13° 10′ 54″	.979 081	.953 284	.223 270
39.8°	13° 12′ 53″	.978 977	.953 054	.223 794
39.9°	13° 14′ 51″	.978 872	.952 823	.224 318
40.0°	13° 16′ 50″	.978 766	.952 591	.224 841

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.680 270	.345 777	.050 304	.013 20	.494 036	.041 87	35.0°
.680 351	.345 851	.050 444	.013 28	.494 002	.041 98	35.1°
.680 432	.345 926	.050 584	.013 35	.493 968	.042 08	35.2°
.680 513	.346 000	.050 724	.013 42	.493 934	.042 18	35.3°
.680 595	.346 075	.050 865	.013 50	.493 900	.042 29	35.4°
.680 677	.346 150	.051 005	.013 57	.493 866	.042 39	35.5°
.680 759	.346 226	.051 145	.013 64	.493 831	.042 49	35.6°
.680 841	.346 301	.051 285	.013 72	.493 797	.042 60	35.7°
.680 923	.346 377	.051 425	.013 79	.493 762	.042 70	35.8°
.681 006	.346 453	.051 565	.013 87	.493 728	.042 81	35.9°
.681 089	.346 529	.051 705	.013 94	.493 693	.042 91	36.0°
.681 173	.346 606	.051 845	.014 02	.493 658	.043 01	36.1°
.681 256	.346 683	.051 985	.014 09	.493 623	.043 11	36.2°
.681 340	.346 760	.052 125	.014 17	.493 588	.043 22	36.3°
.681 424	.346 837	.052 265	.014 24	.493 553	.043 32	36.4°
.681 509	.346 915	.052 405	.014 32	.493 518	.043 42	36.5°
.681 594	.346 993	.052 545	.014 39	.493 483	.043 52	36.6°
.681 679	.347 071	.052 685	.014 47	.493 447	.043 63	36.7°
.681 764	.347 149	.052 825	.014 55	.493 412	.043 73	36.8°
.681 849	.347 228	.052 965	.014 62	.493 376	.043 83	36.9°
.681 935	.347 307	.053 104	.014 70	.493 341	.043 93	37.0°
.682 021	.347 386	.053 244	.014 78	.493 305	.044 03	37.1°
.682 107	.347 465	.053 384	.014 85	.493 269	.044 14	37.2°
.682 194	.347 545	.053 523	.014 93	.493 233	.044 24	37.3°
.682 281	.347 625	.053 663	.015 01	.493 197	.044 34	37.4°
.682 368	.347 705	.053 803	.015 09	.493 161	.044 44	37.5°
.682 455	.347 785	.053 942	.015 16	.493 125	.044 54	37.6°
.682 543	.347 866	.054 082	.015 24	.493 089	.044 64	37.7°
.682 631	.347 947	.054 221	.015 32	.493 052	.044 74	37.8°
.682 719	.348 028	.054 361	.015 40	.493 016	.044 84	37.9°
.682 808	.348 109	.054 500	.015 48	.492 979	.044 94	38.0°
.682 896	.348 191	.054 640	.015 55	.492 943	.045 04	38.1°
.682 986	.348 273	.054 779	.015 63	.492 906	.045 14	38.2°
.683 075	.348 355	.054 919	.015 71	.492 869	.045 24	38.3°
.683 164	.384 437	.055 058	.015 79	.492 832	.045 34	38.4°
.683 254	.348 520	.055 197	.015 87	.492 795	.045 44	38.5°
.683 344	.348 603	.055 336	.015 95	.492 758	.045 54	38.6°
.683 435	.348 686	.055 476	.016 03	.492 721	.045 64	38.7°
.683 526	.348 769	.055 615	.016 11	.492 683	.045 74	38.8°
.683 617	.348 853	.055 754	.016 19	.492 646	.045 84	38.9°
.683 708	.348 937	.055 893	.016 27	.492 608	.045 94	39.0°
.683 799	.349 021	.056 032	.016 35	.492 571	.046 04	39.1°
.683 891	.349 106	.056 171	.016 43	.492 533	.046 14	39.2°
.683 983	.349 190	.056 310	.016 51	.492 495	.046 24	39.3°
.684 076	.349 275	.056 450	.016 59	.492 458	.046 34	39.4°
.684 168	.349 361	.056 589	.016 67	.492 420	.046 43	39.5°
.684 261	.349 446	.056 727	.016 75	.492 382	.046 53	39.6°
.684 354	.349 532	.056 866	.016 83	.492 343	.046 63	39.7°
.684 448	.349 618	.057 005	.016 92	.492 305	.046 73	39.8°
.684 542	.349 704	.057 144	.017 00	.492 267	.046 83	39.9°
.684 636	.349 791	.057 283	.017 08	.492 229	.046 92	40.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
40.0°	13° 16′ 50″	.978 766	.952 591	.224 841
40.1°	13° 18′ 48″	.978 661	.952 359	.225 365
40.2°	13° 20′ 47″	.978 555	.952 127	.225 888
40.3°	13° 22′ 46″	.978 449	.951 893	.226 410
40.4°	13° 24′ 44″	.978 343	.951 660	.226 933
40.5°	13° 26′ 43″	.978 236	.951 426	.227 455
40.6°	13° 28′ 41″	.978 130	.951 191	.227 977
40.7°	13° 30′ 40″	.978 023	.950 956	.228 498
40.8°	13° 32′ 38″	.977 915	.950 720	.229 019
40.9°	13° 34′ 37″	.977 808	.950 484	.229 540
41.0°	13° 36′ 35″	.977 700	.950 247	.230 061
41.1°	13° 38′ 34″	.977 592	.950 010	.230 581
41.2°	13° 40′ 32″	.977 484	.949 772	.231 102
41.3°	13° 42′ 31″	.977 375	.949 533	.231 621
41.4°	13° 44′ 29″	.977 266	.949 294	.232 141
41.5°	13° 46′ 28″	.977 157	.949 055	.232 660
41.6°	13° 48′ 26″	.977 048	.948 815	.233 179
41.7°	13° 50′ 25″	.976 938	.948 575	.233 698
41.8°	13° 52′ 23″	.976 828	.948 334	.234 216
41.9°	13° 54′ 22″	.976 718	.948 092	.234 734
42.0°	13° 56′ 20″	.976 608	.947 850	.235 252
42.1°	13° 58′ 18″	.976 497	.947 608	.235 769
42.2°	14° 00′ 17″	.976 387	.947 365	.236 286
42.3°	14° 02′ 15″	.976 276	.947 121	.236 803
42.4°	14° 04′ 14″	.976 164	.946 877	.237 320
42.5°	14° 06′ 12″	.976 053	.946 632	.237 836
42.6°	14° 08′ 10″	.975 941	.946 387	.238 352
42.7°	14° 10′ 09″	.975 829	.946 142	.238 868
42.8°	14° 12′ 07″	.975 716	.945 895	.239 383
42.9°	14° 14′ 06″	.975 604	.945 649	.239 898
43.0°	14° 16′ 04″	.975 491	.945 401	.240 413
43.1°	14° 18′ 02″	.975 378	.945 154	.240 927
43.2°	14° 20′ 01″	.975 264	.944 906	.241 442
43.3°	14° 21′ 59″	.975 151	.944 657	.241 956
43.4°	14° 23′ 57″	.975 037	.944 408	.242 469
43.5°	14° 25′ 56″	.974 923	.944 158	.242 982
43.6°	14° 27′ 54″	.974 808	.943 908	.243 495
43.7°	14° 29′ 52″	.974 694	.943 657	.244 008
43.8°	14° 31′ 50″	.974 579	.943 405	.244 520
43.9°	14° 33′ 49″	.974 464	.943 154	.245 032
44.0°	14° 35′ 47″	.974 348	.942 901	.245 544
44.1°	14° 37′ 45″	.974 233	.942 648	.246 055
44.2°	14° 39′ 44″	.974 117	.942 395	.246 566
44.3°	14° 41′ 42″	.974 001	.942 141	.247 077
44.4°	14° 43′ 40″	.973 884	.941 887	.247 588
44.5°	14° 45′ 38″	.973 768	.941 632	.248 098
44.6°	14° 47′ 37″	.973 651	.941 377	.248 608
44.7°	14° 49′ 35″	.973 534	.941 121	.249 117
44.8°	14° 51′ 33″	.973 416	.940 864	.249 627
44.9°	14° 53′ 31″	.973 299	.940 607	.250 135
45.0°	14° 55′ 29″	.973 181	.940 350	.250 644

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.684 636	.349 791	.057 283	.017 08	.492 229	.046 92	40.0°
.684 730	.349 878	.057 422	.017 16	.492 190	.047 02	40.1°
.684 825	.349 965	.057 561	.017 24	.492 151	.047 12	40.2°
.684 920	.350 052	.057 699	.017 33	.492 113	.047 22	40.3°
.685 015	.350 140	.057 838	.017 41	.492 074	.047 31	40.4°
.685 110	.350 228	.057 977	.017 49	.492 035	.047 41	40.5°
.685 206	.350 316	.058 115	.017 57	.491 996	.047 51	40.6°
.685 302	.350 404	.058 254	.017 66	.491 957	.047 60	40.7°
.685 398	.350 493	.058 393	.017 74	.491 918	.047 70	40.8°
.685 495	.350 582	.058 531	.017 82	.491 879	.047 80	40.9°
.685 592	.350 671	.058 670	.017 91	.491 839	.047 89	41.0°
.685 689	.350 761	.058 808	.017 99	.491 800	.047 99	41.1°
.685 786	.350 851	.058 946	.018 07	.491 760	.048 08	41.2°
.685 884	.350 941	.059 085	.018 16	.491 721	.048 18	41.3°
.685 982	.351 031	.059 223	.018 24	.491 681	.048 28	41.4°
.686 081	.351 121	.059 362	.018 33	.491 641	.048 37	41.5°
.686 179	.351 212	.059 500	.018 41	.491 602	.048 47	41.6°
.686 278	.351 303	.059 638	.018 50	.491 562	.048 56	41.7°
.686 377	.351 395	.059 776	.018 58	.491 521	.048 66	41.8°
.686 477	.351 486	.059 915	.018 67	.491 481	.048 75	41.9°
.686 576	.351 578	.060 053	.018 75	.491 441	.048 85	42.0°
.686 677	.351 671	.060 191	.018 84	.491 401	.048 94	42.1°
.686 777	.351 763	.060 329	.018 92	.491 360	.049 04	42.2°
.686 878	.351 856	.060 467	.019 01	.491 320	.049 13	42.3°
.686 978	.351 949	.060 605	.019 09	.491 279	.049 22	42.4°
.687 080	.352 042	.060 743	.019 18	.491 239	.049 32	42.5°
.687 181	.352 136	.060 881	.019 26	.491 198	.049 41	42.6°
.687 283	.352 229	.061 019	.019 35	.491 157	.049 51	42.7°
.687 385	.352 324	.061 157	.019 44	.491 116	.049 60	42.8°
.687 487	.352 418	.061 295	.019 52	.491 075	.049 69	42.9°
.687 590	.352 513	.061 433	.019 61	.491 034	.049 79	43.0°
.687 693	.352 608	.061 571	.019 70	.490 992	.049 88	43.1°
.687 796	.352 703	.061 708	.019 79	.490 951	.049 97	43.2°
.687 900	.352 798	.061 846	.019 87	.490 910	.050 06	43.3°
.688 004	.352 894	.061 984	.019 96	.490 868	.050 16	43.4°
.688 108	.352 990	.062 122	.020 05	.490 827	.050 25	43.5°
.688 212	.353 086	.062 259	.020 14	.490 785	.050 34	43.6°
.688 317	.353 183	.062 397	.020 22	.490 743	.050 43	43.7°
.688 422	.353 280	.062 534	.020 31	.490 701	.050 53	43.8°
.688 527	.353 377	.062 672	.020 40	.490 659	.050 62	43.9°
.688 633	.353 474	.062 809	.020 49	.490 617	.050 71	44.0°
.688 739	.353 572	.062 947	.020 58	.490 575	.050 80	44.1°
.688 845	.353 670	.063 084	.020 67	.490 533	.050 89	44.2°
.688 952	.353 768	.063 222	.020 75	.490 491	.050 98	44.3°
.689 059	.353 867	.063 359	.020 84	.490 448	.051 08	44.4°
.689 166	.353 966	.063 496	.020 93	.490 406	.051 17	44.5°
.689 273	.354 065	.063 634	.021 02	.490 363	.051 26	44.6°
.689 381	.354 164	.063 771	.021 11	.490 320	.051 35	44.7°
.689 489	.354 264	.063 908	.021 20	.490 278	.051 44	44.8°
.689 597	.354 364	.064 045	.021 29	.490 235	.051 53	44.9°
.689 706	.354 464	.064 182	.021 38	.490 192	.051 62	45.0°

[20] MAINTENANCE OF SURFACE.

(a) Elevation of Curves:

The approximate formula

$$E = .00066\ DS^2$$

in which

E = Elevation in inches of the outer rail at the gage line,
D = Degree of Curve,
and S = Velocity in miles per hour,

will give essentially correct theoretical elevation for the outer rail of curves and is recommended for ordinary practice.

This formula will give results which are expressed in the following table:

ELEVATION OF OUTER RAIL IN INCHES.

Degree of Curve.	Velocity in Miles per Hour.													Degree of Curve.
	10	15	20	25	30	35	40	45	50	55	60	65	70	
1	0	⅛	¼	⅜	⅝	¾	1⅛	1⅜	1⅝	2	2⅜	2¾	3¼	1
2	⅛	⅜	½	⅞	1⅛	1⅝	2⅛	2⅝	3¼	4	4¾	5½	6½	2
3	¼	½	¾	1¼	1¾	2⅜	3⅛	4	4⅞	6	7⅛	8⅜	9¾	3
4	¼	⅝	1	1⅝	2⅜	3¼	4¼	5⅜	6⅝	8	9½	......	......	4
5	⅜	¾	1¼	2	3	4	5¼	6⅝	8¼	......	......	......	......	5
6	⅜	1	1⅝	2½	3½	4⅞	6¼	8	......	......	......	......	......	6
7	½	1⅛	1⅞	2⅞	4⅛	5⅝	7⅜	......	......	......	......	......	......	7
8	½	1¼	2⅛	3¼	4¾	6½	8⅜	......	......	......	......	......	......	8
9	⅝	1⅜	2⅜	3¾	5⅜	7¼	......	......	......	......	......	......	......	9
10	¾	1½	2⅝	4⅛	5⅞	8⅛	......	......	......	......	......	......	......	10
11	¾	1¾	2⅞	4½	6½	8⅞	......	......	......	......	......	......	......	11
12	⅞	1⅞	3⅛	4⅞	7⅛	......	......	......	......	......	......	......	......	12
13	⅞	2	3⅜	5⅜	7¾	......	......	......	......	......	......	......	......	13
14	1	2⅛	3⅝	5¾	8⅜	......	......	......	......	......	......	......	......	14
15	1	2¼	3⅞	6¼	8⅞	......	......	......	......	......	......	......	......	15
16	1⅛	2½	4¼	6⅝	......	......	......	......	......	......	......	......	......	16
17	1¼	2⅝	4½	7	......	......	......	......	......	......	......	......	......	17
18	1¼	2¾	4¾	7½	......	......	......	......	......	......	......	......	......	18
19	1⅜	2⅞	5	7¾	......	......	......	......	......	......	......	......	......	19
20	1⅜	3	5¼	8⅛	......	......	......	......	......	......	......	......	......	20

Since the elevation required is a function of the train speed this speed is the first element to be determined.

In general, in determining speed, consideration should be given to the traffic and the elevation fixed to give the greatest degree of economy in train operation.

Where easement curves are used the elevation should be attained and run out as prescribed under "Maintenance of Line, (b) Curves; Use of Easement Curves."

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[20] Adopted, Vol. 3, 1902, pp. 56-59, 78-87; Vol. 5, 1904, pp. 528-533, 535, 562, 563; Vol. 6, 1905, pp. 754-757, 759-761; Vol. 11, Part 2, 1910, pp. 935, 944; Vol. 12, Part 1, 1911, pp. 402, 465; Vol. 16, 1915, pp. 732, 1145.

Where easement curves are not used the full elevation should be maintained throughout a simple curve and throughout the sharper curve of a compound curve, if possible, the elevation being attained or run out on the tangent and lighter curve respectively at a rate approximately one inch in a distance in feet equal to 1¾ times the speed in miles per hour.

Ordinarily an elevation of 8 inches should not be exceeded. Speed of trains should be regulated to conform to the maximum elevation used.

The inner rail should be maintained at grade.

(b) Vertical Curves:

The use of vertical curves to connect changes in gradient is recommended.

The length should be determined by the gradients to be connected. On Class A roads rates of change of 0.1 per station on summits and 0.05 per station in sags should not be exceeded. On minor roads 0.2 per station on summits and 0.1 per station in sags may be used.

(c) Proper Methods of Tamping:

(1) *Earth or Clay Ballast:*

Tools: Shovel equipped with iron cuff or handle; broad-faced tamping bars.

Method: Tamp each tie from 18 inches inside of the rail to end of tie with handle of shovel or tamping bar. If possible, tamp the end of the tie outside of rail first and let train pass over before tamping inside of rail; give special attention to tamping under the rail; tamp center of ties loosely with the blade of the shovel; the dirt or clay between the ties should be placed in layers and firmly packed with feet or otherwise, so that it will quickly shed the water; the earth should not be banked above the bottom of the ends of the ties; the filling between the ties should not touch the rail and should be as high as, or higher than, the top of the ties in the middle of the track.

(2) *Cinder Ballast (Railroad Product):*

Tools: Shovel, tamping bar or tamping pick.

Method: Same as for gravel.

(3) *Burnt Clay Ballast:*

Tools: Shovel only in soft material. When burnt very hard, tamping pick or bar should be used.

Method: Tamp 15 inches inside of rail to end of tie, tamping end of tie first, letting train pass before tamping inside of rail; tamp center loosely; tamp well between the ties; dress ballast same as for earth or cinders.

(4) *Broken Stone or Furnace Slag:*

Tools: Shovel, tamping pick, stone forks.

Method: Tamp 15 inches inside of rail to end of tie; if possible, tamp end of tie outside of rail first and allow train to pass over before tamping inside of rail; tamp well under the rail; tamp well under ties from end of same; do not tamp center of tie; finish in accordance with standard section.

(5) *Chats, Gravel or Chert Ballast:*

Tools: Shovel, tamping pick or tamping bar. For light traffic, shovel tamping is sufficient. For heavy traffic, the tamping pick or tamping bar should be used. The tamping bar is recommended instead of the tamping pick for ordinary practice.

Method: Tamp solid from a point 15 inches inside of rail to the end of the tie; if possible, tamp the end of the tie outside of the rail first and allow train to pass over before tamping inside of rail; care should be taken not to disturb the old bed. Tie should be tamped solidly from the end, using pick or tamping bar. After train has passed, the center of the tie should be loosely tamped with the blade of the shovel; dress same as stone ballast.

(6) *General:*

When not surfacing out of face, as in case of picking up low joints or other low places, the general level of the track should not be disturbed. Where the rails are out of level, but where the difference in elevation is not excessive and is uniform over long stretches of track, a difference in elevation between the two rails of ⅜ inch may be permitted to continue until such time as the track would ordinarily be surfaced out of face.

[21] SPEEDS OF TRAINS THROUGH CURVES AND TURNOUTS.

Diagrams of speeds of trains through curves and level turnouts are shown in following pages.

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[21] Adopted, Vol. 15, 1914, pp. 594, 1063.

[22] RELATIVE SPEEDS THROUGH LEVEL TURNOUTS.

The following table shows relative speeds through level turnouts, to give the equivalent riding conditions to track elevated three inches less than theoretically required:

TURNOUT		SPEED Miles per Hour
Frog Number	Length of Switch	
4	11	9
5	11	12
6	11	13
7	16.5	17
8-10	16.5	20
11-14	22	27
15	33	37
16-24	33	40

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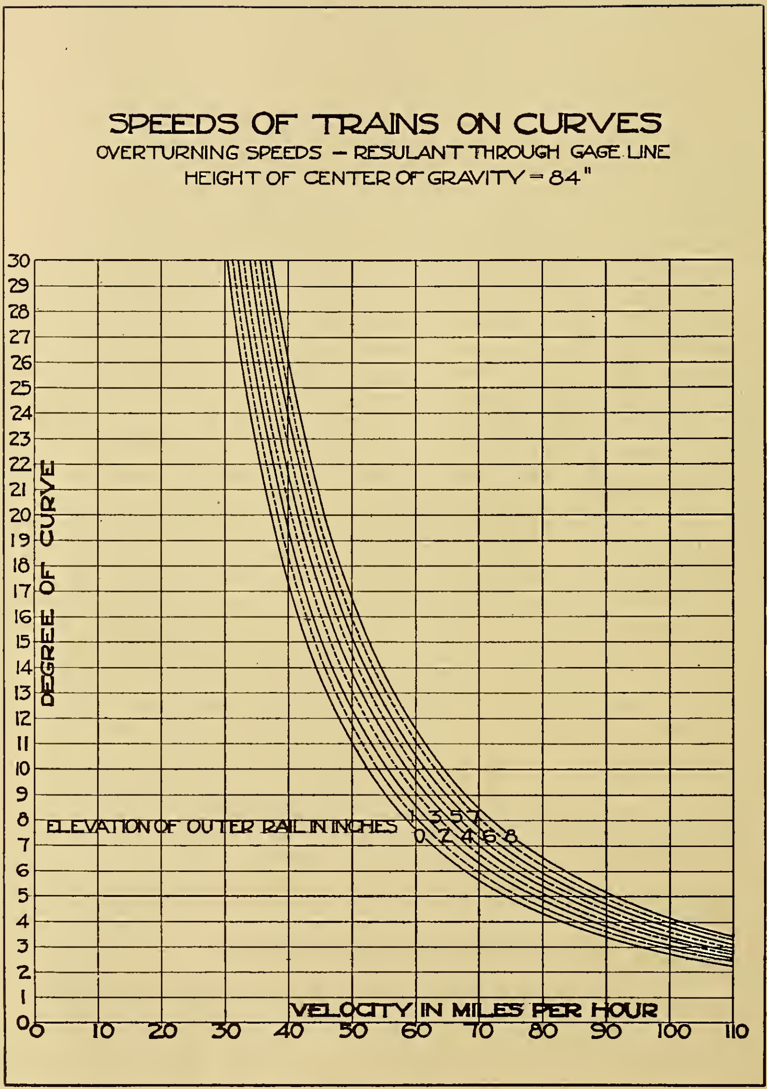
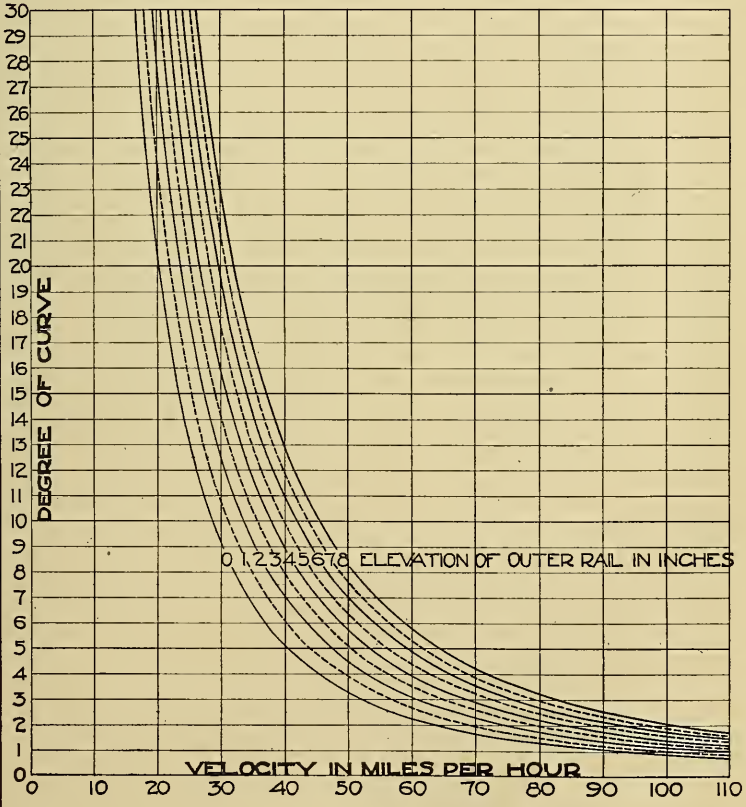
[22] Adopted, Vol. 15, 1914, pp. 594. 1063.


SPEEDS OF TRAINS ON CURVES
OVERTURNING SPEEDS – RESULANT THROUGH GAGE LINE
HEIGHT OF CENTER OF GRAVITY = 84"
DEGREE OF CURVE
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
ELEVATION OF OUTER RAIL IN INCHES
1 3 5 7
0 2 4 6 8
VELOCITY IN MILES PER HOUR
0
10
20
30
40
50
60
70
80
90
100
110



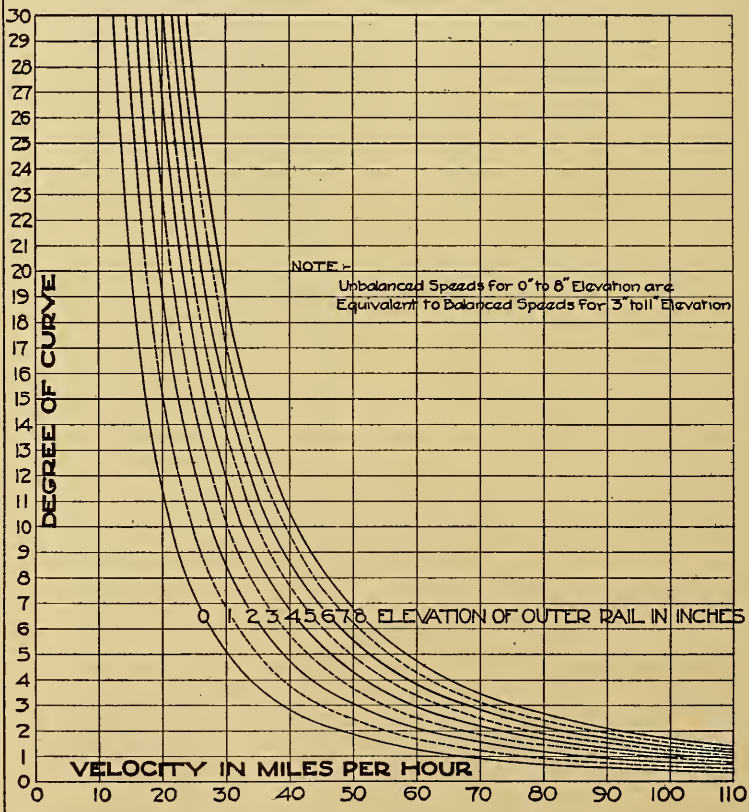
SPEEDS OF TRAINS ON CURVES

RESULTANT THROUGH EDGE OF MIDDLE THIRD

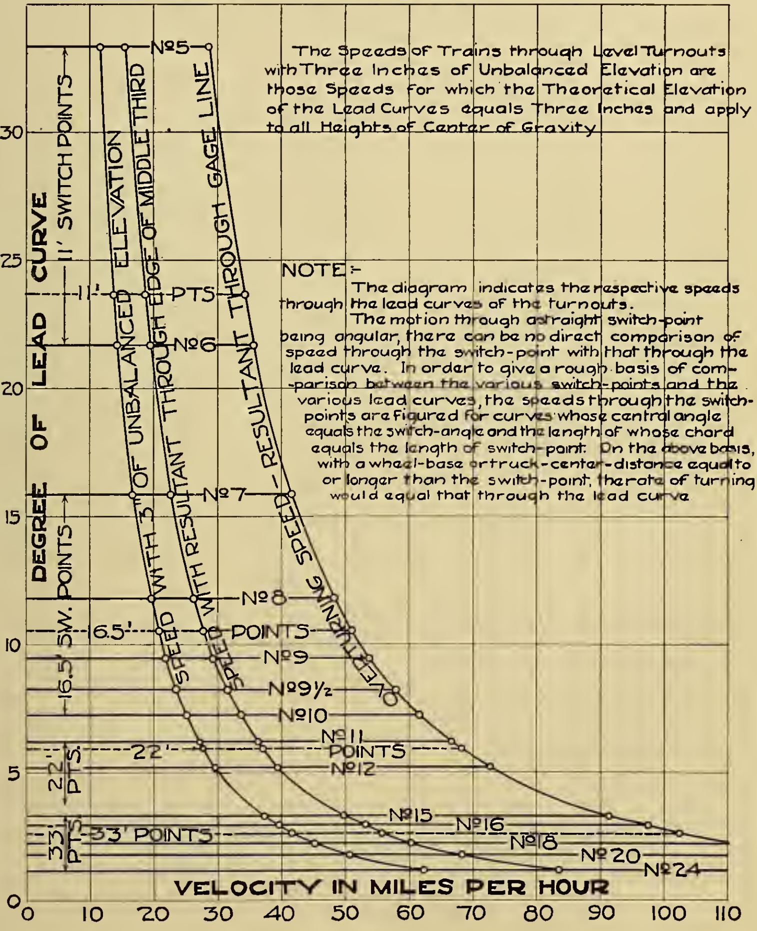
HEIGHT OF CENTER OF GRAVITY = 84"

SPEEDS OF TRAINS ON CURVES

UNBALANCED ELEVATION = 3"
ALL HEIGHTS OF CENTER OF GRAVITY
THOSE SPEEDS OF TRAINS ON CURVES HAVING AN ELEVATION
OF THREE INCHES LESS THAN THE THEORETICAL ELEVATION



NOTE:–
Unbalanced Speeds for 0" to 8" Elevation are Equivalent to Balanced Speeds for 3" to 11" Elevation



SPEEDS OF TRAINS THROUGH LEVEL TURNOUTS

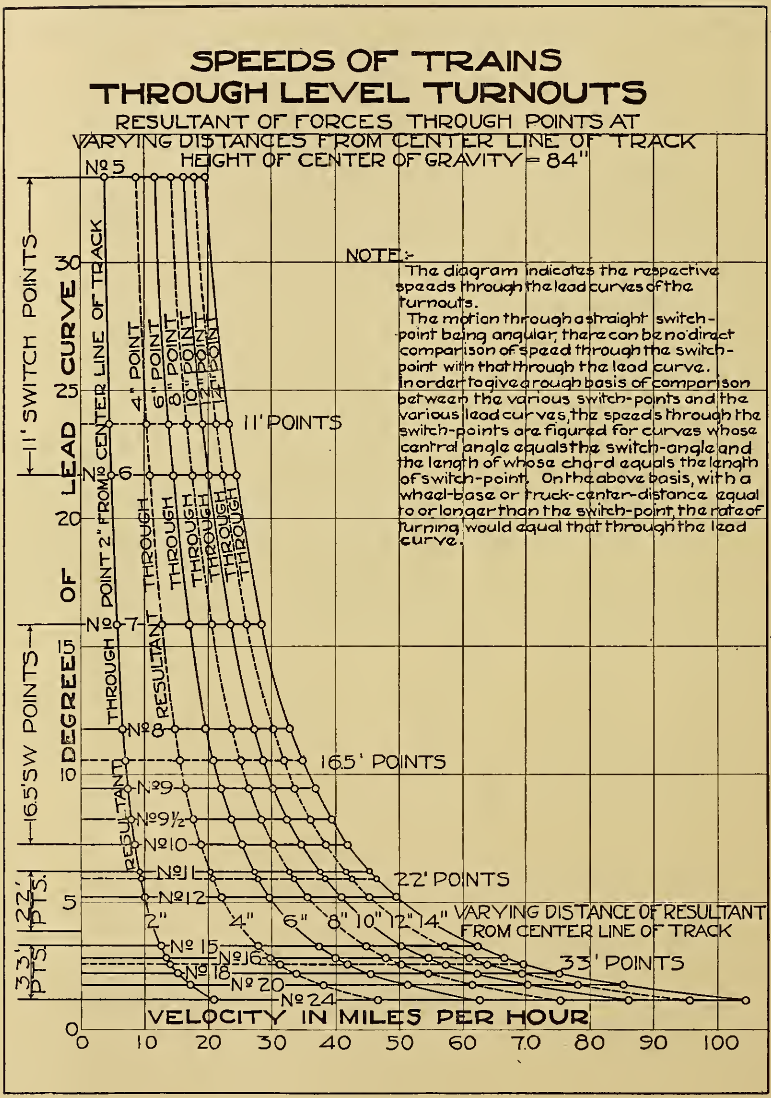
HEIGHT OF CENTER OF GRAVITY = 84"

The Speeds of Trains through Level Turnouts with Three Inches of Unbalanced Elevation are those Speeds for which the Theoretical Elevation of the Lead Curves equals Three Inches and apply to all Heights of Center of Gravity

NOTE:-

The diagram indicates the respective speeds through the lead curves of the turnouts.

The motion through a straight switch-point being angular, there can be no direct comparison of speed through the switch-point with that through the lead curve. In order to give a rough basis of comparison between the various switch-points and the various lead curves, the speeds through the switch-points are figured for curves whose central angle equals the switch-angle and the length of whose chord equals the length of switch-point. On the above basis, with a wheel-base or truck-center-distance equal to or longer than the switch-point, the rate of turning would equal that through the lead curve



SPEEDS OF TRAINS THROUGH LEVEL TURNOUTS

RESULTANT OF FORCES THROUGH POINTS AT VARYING DISTANCES FROM CENTER LINE OF TRACK

HEIGHT OF CENTER OF GRAVITY = 84"

NOTE:-

The diagram indicates the respective speeds through the lead curves of the turnouts.

The motion through a straight switch-point being angular, there can be no direct comparison of speed through the switch-point with that through the lead curve. In order to give a rough basis of comparison between the various switch-points and the various lead curves, the speeds through the switch-points are figured for curves whose central angle equals the switch-angle and the length of whose chord equals the length of switch-point. On the above basis, with a wheel-base or truck-center-distance equal to or longer than the switch-point, the rate of turning would equal that through the lead curve.

[23] MAINTENANCE OF GAGE.

(a) Appliances and methods used to prevent spreading of track and canting of rails on curves:

(1) Tie plates are recommended in all cases where economy in maintenance will result from their use.

(2) Shoulder tie plates are recommended in preference to rail braces except for guard rails and stock rails at switches where braces should be used.

(3) For heavy traffic, shoulder tie plates should be used on all ties on curves.

(4) For medium traffic, shoulder tie plates should be used on all ties on curves over three degrees.

(5) For light traffic, where tie plates are not used, the outside of both rails on curves should be double spiked when necessary.

(b) General:

(1) The gage (tool) used should be the standard gage recommended.

(2) Within proper limits, a slight variation of gage from the standard is not seriously objectionable, provided the variation is uniform and constant over long distances. Under ordinary conditions it is not necessary to regage track if the increase in gage has not amounted to more than one-half inch, providing such increase is uniform.

(3) Wide gage, due to worn rail, within the safe limits of wear, need not be corrected until the excess over the gage is equal to ½ inch; it should be corrected by closing in or by interchanging the low and high rails.

(4) Where track is to be spiked to standard gage, the rail should be held against the gage with a bar while the spike is being driven.

(5) Spikes should be started vertically and square, and so driven that the face of the spike shall come in contact with the base of rail; the spike should never have to be straightened while being driven.

(6) The outside spikes of both rails should be near one edge of the tie, and the inside spikes near the other. The inside and out-

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[23] Adopted, Vol. 5, 1904, pp. 534, 535, 563-569; Vol. 6, 1905, pp. 749, 750, 757, 759-761; Vol. 7, 1906, pp. 654, 664; Vol. 10, Part 1, 1909, pp. 398, 400, 467; Vol. 11, Part 2, 1910, pp. 934, 935, 944-946; Vol. 12, Part 1, 1911, pp. 402, 465; Vol. 16, 1915, pp. 732, 1145.

side spikes should be spaced as far apart as the face and character of the tie will permit. The ordinary practice should be to drive the spike 2½ inches from the outer edge of the tie. The old spike holes should be plugged.

[24] REQUISITES FOR SWITCHSTANDS.

(1) There should be no lost motion in parts.

(2) Stands should have an adjustable throw on the foot.

(3) The operating lever of ground stands should work parallel with the track.

(4) Throwing apparatus should be so arranged that when the switch is set for movement of a train, it will be thrown to an extreme position and the throwing rod be locked independent of the latch on the stand lever.

(5) The stand should be snowproof.

(6) The connection between the throwing rod and the stand should be so arranged that it will be impossible to separate the throwing rod from the stand when the stand is set up in working position.

(7) The stand should be so arranged that it can be easily inspected.

(8) The target should not show clear signal for main track movements unless the points are up snug against the stock rail.

(9) The targets shall conform to drawing No. —.

[25] LENGTHS OF SWITCHES.

For all new work, 16½-foot switch points are recommended for frogs over No. 6 up to and including No. 10; 22-foot points for frogs over No. 10 up to and including No. 14; 33-foot points for frogs over No. 14 and 11-foot points for No. 6 and under where they are required.

Nos. 8, 11 and 16 frogs are recommended as meeting all general requirements for yards, main track switches and junctions; new work should be laid out, so far as practicable, for these three frogs, so as to effect the gradual elimination of frogs of other numbers, lessen the cost of manufacture and decrease the amount of stock carried.

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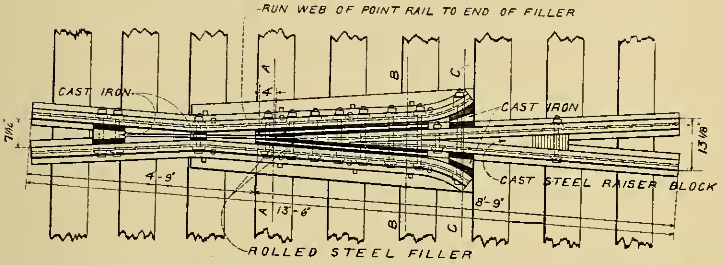
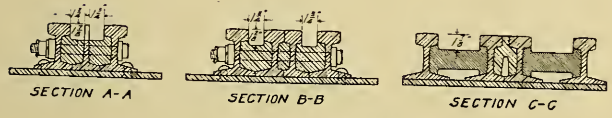
[24] Adopted, Vol. 5, 1904, pp. 525, 526, 571; Vol. 6, 1905, pp. 757, 758, 760.

[25] Adopted, Vol. 13, 1912, pp. 374, 375, 979.

[26] PLANS FOR FROGS AND SWITCHES.

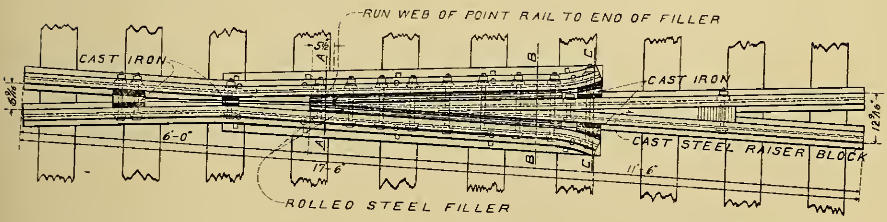


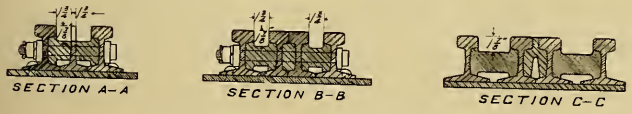


SECTION A-A SECTION B-B SECTION C-C

NO. 8 RIGID FROG

WEIGHT OF RAIL	SIZE OF FROG BOLTS
100	1⅛"
90	1⅛"
80	1⅛"
70	1"
60	⅞"





SECTION A-A SECTION B-B SECTION C-C

NO. 11 RIGID FROG

WEIGHT OF RAIL	SIZE OF FROG BOLTS
100	1⅛"
90	1⅛"
80	1⅛"
70	1"
60	⅞"

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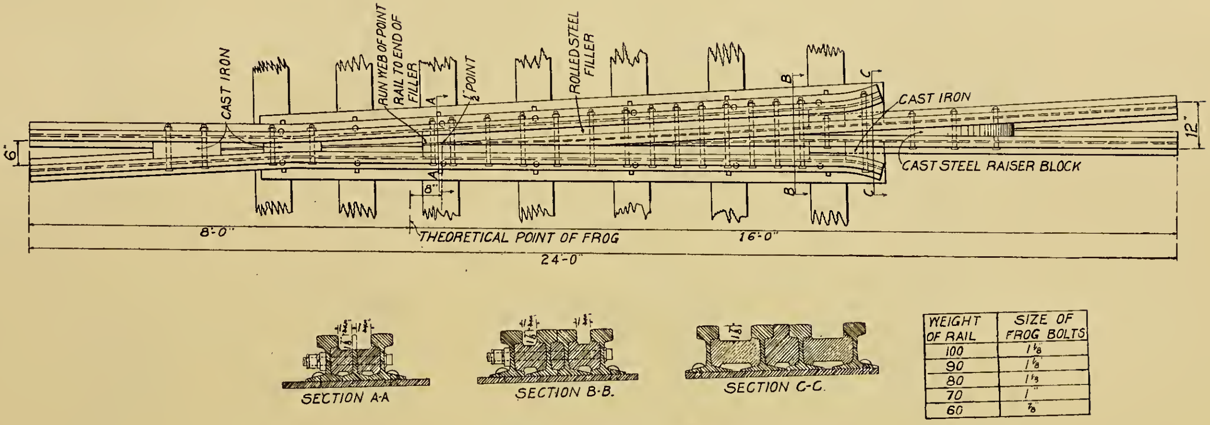
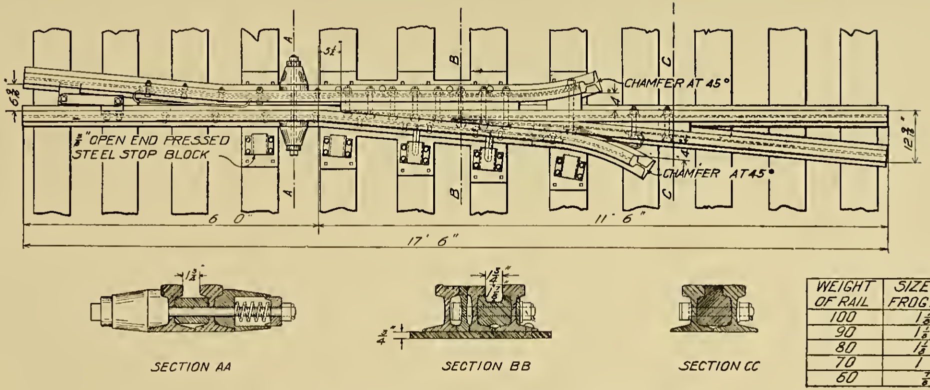
[26] Adopted, Vol. 13, 1912, pp. 374, 379, 380, 383, 384, 385, 968.



WEIGHT OF RAIL	SIZE OF FROG BOLTS
100	1⅛"
90	1⅛"
80	1⅛"
70	1"
60	⅞"

NO 16 RIGID FROG



WEIGHT OF RAIL	SIZE OF FROG BOLTS
100	1 1/8"
90	1 1/8"
80	1 1/8"
70	1"
60	7/8"

NO. 11 SPRING FROG

[27] FROG BLOCKING.

The heel of a frog should be made with a steel filler block, to fit the section of rail, securely bolted, and with the outer end of filler planed off ⅜ inch below top of rail to act as a riser for the outer edge of worn treads.

The wings and throats of all frogs, switches and guard rails, should be blocked with metal or wood block, shaped to fit rail sections, and to give 1⅞-inch vertical flange clearance, and be bolted or otherwise secured.

[28] SPECIFICATIONS FOR FROGS, CROSSINGS AND SWITCHES.

GENERAL INSTRUCTIONS.

1. The Company will furnish to the manufacturer specifications and drawings. The drawings will show rail sections, splice drilling, angles, alinement, general dimensions and such details as the Company may desire.

2. When requested, manufacturers shall submit for approval detail drawings showing construction and dimensions of all parts to be furnished in accordance with these specifications. Conventional shading shall be used in sectional drawings. All dimensions and distances shall be shown plainly in figures. The title shall be placed in the lower right-hand corner.

3. The detail drawings shall be on sheets 22 inches wide, with a border line ½ inch from the top, bottom and right-hand edge, and 1½ inches from the left-hand edge. The standard length of sheets shall be 30 inches except that when necessary, longer sheets may be used and folded back to the standard length. Drawings of one subject only shall appear on a sheet. Scale of general drawings shall be 1½ inches = 1 foot; details not less than 3 inches = 1 foot.

4. The drawings of the Company and the manufacturers' drawings approved by the Company shall be a part of the specifications. Anything which is not shown on the drawings but which is mentioned in the specifications, or vice versa, or anything not expressly set forth in either but

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[27] Adopted, Vol. 11, Part 2, 1910, pp. 939, 942, 946; Vol. 16, 1915, pp. 729, 1145.

[28] Adopted, Vol. 13, 1912, pp. 375-386, 980; Vol. 16, 1915, pp. 733, 1145.

which is reasonably implied, shall be furnished the same as if specifically shown and mentioned in both. Should anything be omitted from the drawings or specifications that is necessary for a clear understanding of the work, or should any error appear in either the drawings or specifications affecting the work, it shall be the duty of the manufacturer to notify the Company and he shall not proceed with the work until instructed to do so by the Company.

INSPECTION.

5. Material and workmanship shall be at all times subject to inspection by a duly authorized representative of the Company, who will examine the material before it is worked in the shop. He will inspect the work during the progress and will also inspect the finished product, with power to reject materials and workmanship found to be unsatisfactory. He shall have free access to the shops and mills at any and all times during the progress of the work.

6. The acceptance of any material by an inspector shall not prevent subsequent rejection if found defective after delivery or during the progress of the work, and such defective material if furnished by the manufacturer shall be replaced by him at his own expense.

7. All facilities, labor and tools necessary for the shop inspection shall be furnished at the expense of the manufacturer.

8. When the manufacturer furnishes the rails, he shall supply the Company with a certificate of inspection made by some competent person acceptable to the Company.

MATERIAL.

Rail.

9. No. 1 rail, of the section ordered, as called for by the specifications, shall be used.

Fillers.

10. Fillers between the main and wing rails and between the main and easer rails shall be rolled steel. Throat filler blocks, not presenting a running surface, may be cast-iron.

Raiser Blocks.

11. Raiser blocks shall be hard cast steel.

Foot Guards.

12. Metallic foot guards shall be either cast-iron, malleable iron or cast steel, except that strap foot guards shall be rolled steel. Wooden foot guards shall be of best quality hardwood.

Bolts.

13. Bolts shall be of double refined iron, mild steel, nickel or other alloy steel or heat-treated alloy steel. Both metal of iron or mild steel shall have a tensile strength of not less than 50,000 lbs. per square inch and an elongation of not less than 15 per cent. in eight inches. When nicked and then broken, the fracture shall be free from flaws and unwelded seams.

Bolt metal of nickel or other alloy steel or heat-treated alloy steel shall meet the respective requirements following:

For untreated nickel or other alloy steel:

Elastic limit, not less than 45,000 lbs. per square inch.
Elongation, not less than 20 per cent. in 2 inches.
Reduction of area, not less than 40 per cent.

For heat-treated or other alloy steel:

Elastic limit, not less than 75,000 lbs. per square inch.
Elongation, not less than 15 per cent. in 2 inches.
Reduction of area, not less than 40 per cent.

Elastic limit shall be not less than 50 per cent. of the ultimate strength. The elastic limit, elongation, and reduction of area may be determined from a finished bolt or from a test piece ½ inch by 2 inches turned from a finished bolt.

Rivets.

14. Rivets shall be made of steel which may contain a maximum of 0.04 per cent. basic phosphorus, 0.04 per cent. acid phosphorus and 0.04 per cent. sulphur. It shall have an ultimate tensile strength of 50,000 lbs. per square inch. It shall bend flat upon itself without fracture and when nicked and bent around a bar of the same diameter as the rivet rod it shall give a gradual break with a fine silky uniform fracture.

Reinforcing Bars.

15. Reinforcing bars shall be of wrought-iron or mild steel.

Plates.

16. Plates shall be of rolled steel.

Springs.

17. Springs shall be of the best quality spring steel and of dimensions and capacity shown on the plans. They shall meet the following tests:

(a) Each spring shall be placed on the testing machine and forced down solid four times.

(b) After the foregoing, each spring shall be placed on end on a flat plate, and the distance between the plate and the other end of the spring measured by means of the standard depth gage; this measurement being the free length of the spring. The free length must conform to the plans within ⅛-inch.

(c) Double springs shall be assembled and a load at least 25 per cent. greater than the rated capacity of the spring shall be applied for thirty seconds. Upon release neither spring must vary from its original free length. If either one does so vary, it shall be rejected.

(d) The inner and outer coils of springs shall be coiled in opposite directions.

Spring Covers.

18. Spring covers shall be made of malleable iron.

Braces.

19. Braces shall be made of *malleable iron.*
forged steel.

Stops and Hold-downs.

20. Stops and hold-downs shall be made of mild steel.

Anti-Creeping Device.

21. Anti-creeping device shall be made of mild steel.

Switch Lugs.

22. Switch lugs shall be mild steel.

Switch Rods.

23. Switch rods shall be mild steel.

WORKMANSHIP.

24. Workmanship shall be first-class. Bends shall be made accurately in arcs of circles and without injury to the material. Welding will not be permitted in any part of the frogs or in the switch rails. Planing shall be such that abutting surfaces will fit accurately together. Ends of rails shall be cut at right angles to the axis of the rail except where otherwise specified. Burrs shall be removed.

25. No paint, tar or other covering shall be used before inspection.

26. The alinement and surface of all finished work shall be even and true, and shall conform to the angles specified.

FROGS.

Fillers.

27. Rolled fillers shall fit the fishing angles and the web of rail for a distance of ½-inch above and below the base and head, respectively, and shall maintain the required flangeway. Throat filler blocks shall fit the rail sufficiently well to maintain the required spacing. Where the brand of the rail interferes with the fit of the filler the brand shall be chipped off. Fillers shall be grooved or cut out to fit over rivet heads.

Heel Raiser Blocks.

28. Heel raiser blocks shall fit the head, base and web of rail as provided under rolled fillers.

Foot Guards.

29. Solid Foot Guards shall fit the rail sufficiently well to maintain the required spacing. Strap guards shall have a minimum thickness of ⅜-inch of the width shown on plan and shall be fastened to the web of the rail by bolts or rivets not less than ¾-inch in diameter.

Bolts.

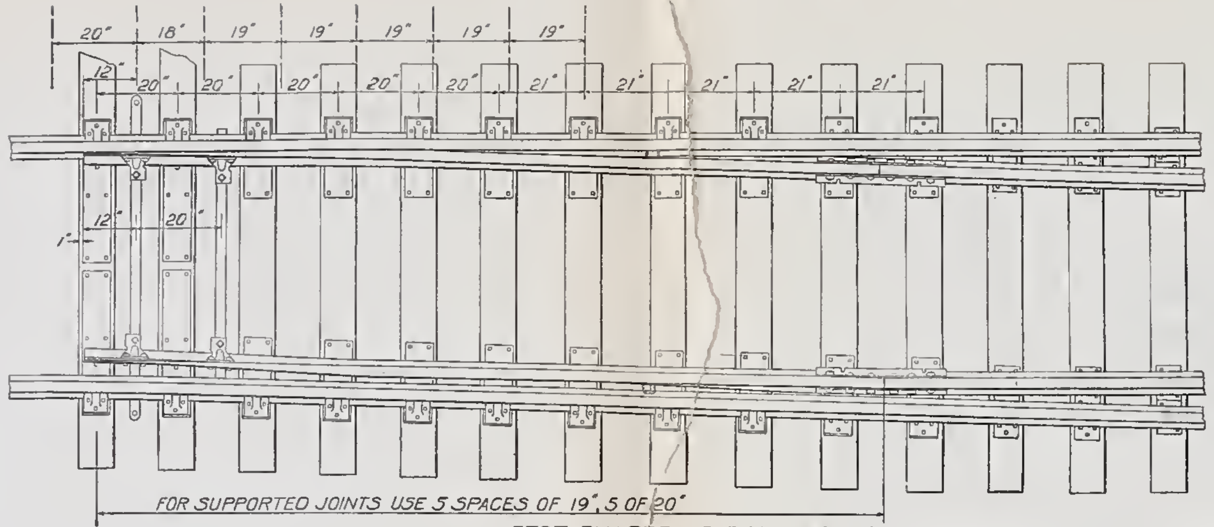
30. Bolts must be round and true to size, with square heads and nuts. Threads must be accurately cut and nuts must have a wrench-tight fit. Each bolt must be provided with an approved head lock and a nutlock of approved pattern large enough to give full bearing for the nut. A ¼-inch cotter pin shall, when required, be placed outside of and close up to the nut after it is tightened. Beveled washers must be used wherever necessary to give the head and nut a full, square bearing. Separate head lock shall be of material not less than $\frac{3}{16}$-inch thick. Washers used under heads may be of such design as to act as head locks. Bolts must be long enough to allow the nuts to be brought out from under the head of the rail, with a suitable washer not less than ½-inch thick, so that the nuts may be readily tightened with an ordinary wrench.

Rivets.

31. The diameters of the rivets shall be of full size shown on plan, and the diameters of the rivet holes shall not be more than

11 FT. SWITCH.
16 FT. 6 IN. SWITCH.
22 FT. SWITCH.
33 FT. SWITCH.

WHEN NO. 1 ROD IS USED AS LOCK ROD, TIES MAY BE SPACED AS SHOWN BY BROKEN LINES. LOCATION OF NO. 2 ROD WILL BE CHANGED.

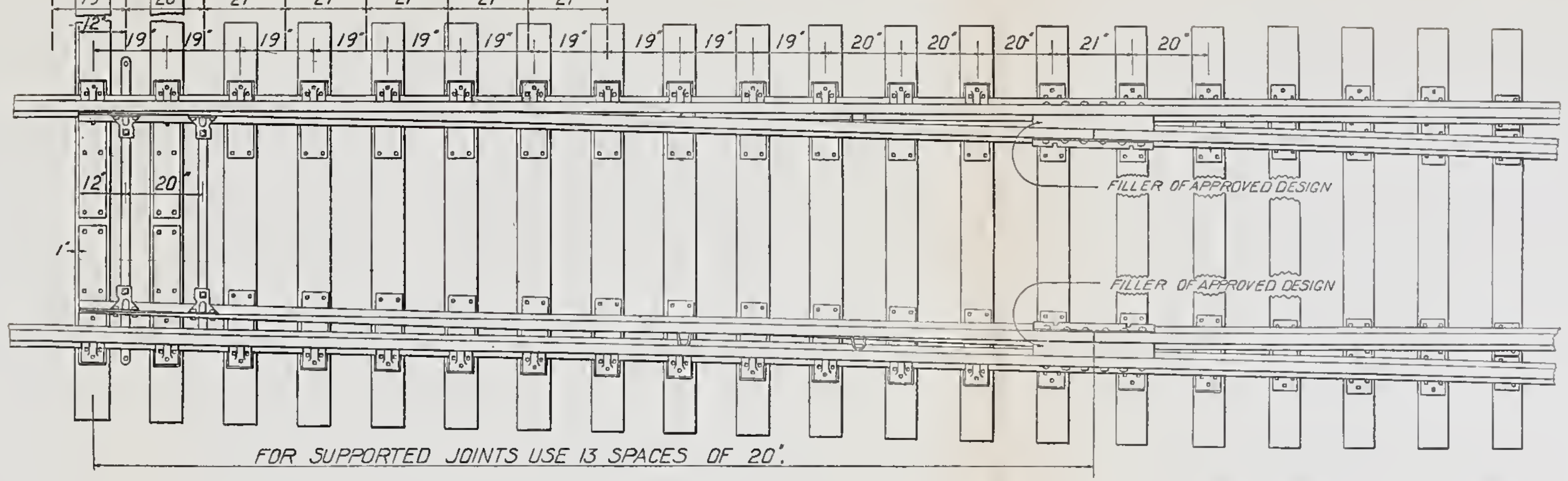


FOR SUPPORTED JOINTS USE 5 SPACES OF 19", 5 OF 20"

FOOT GUARDS AS RECOMMENDED IN SUPPLEMENT TO MANUAL 1912.

16' 6" SWITCH

WHEN NO. 1 ROD IS USED AS LOCK ROD, TIES MAY BE SPACED AS SHOWN BY BROKEN LINES. LOCATION OF NO. 2 ROD WILL BE CHANGED.

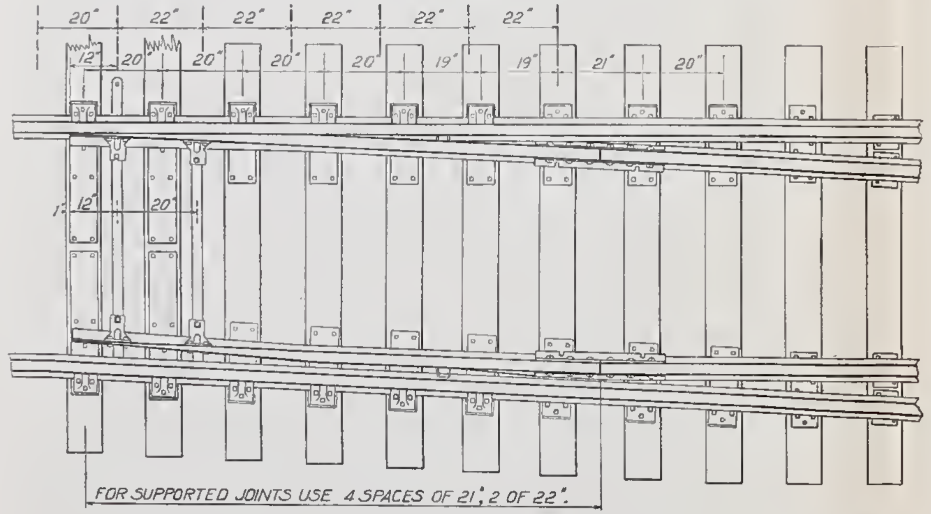


FOR SUPPORTED JOINTS USE 13 SPACES OF 20".

FOOT GUARDS AS RECOMMENDED IN SUPPLEMENT TO MANUAL 1912.

22' SWITCH

WHEN NO. 1 ROD IS USED AS LOCK ROD, TIES MAY BE SPACED AS SHOWN BY BROKEN LINES. LOCATION OF NO. 2 ROD WILL BE CHANGED.

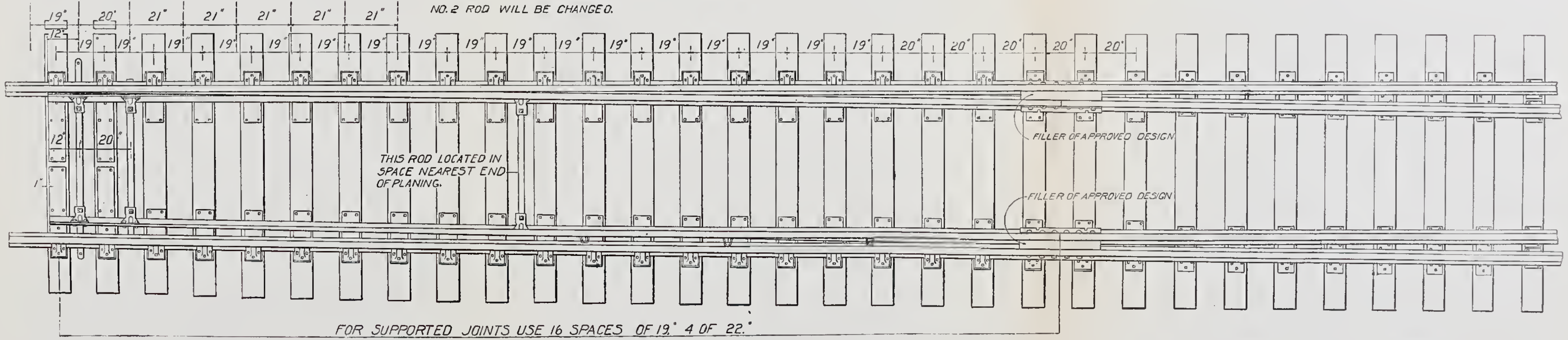


FOR SUPPORTED JOINTS USE 4 SPACES OF 21", 2 OF 22".

FOOT GUARDS AS RECOMMENDED IN SUPPLEMENT TO MANUAL 1912.

11' SWITCH

WHEN NO. 1 ROD IS USED AS LOCK ROD, TIES MAY BE SPACED AS SHOWN BY BROKEN LINES. LOCATION OF NO. 2 ROD WILL BE CHANGED.



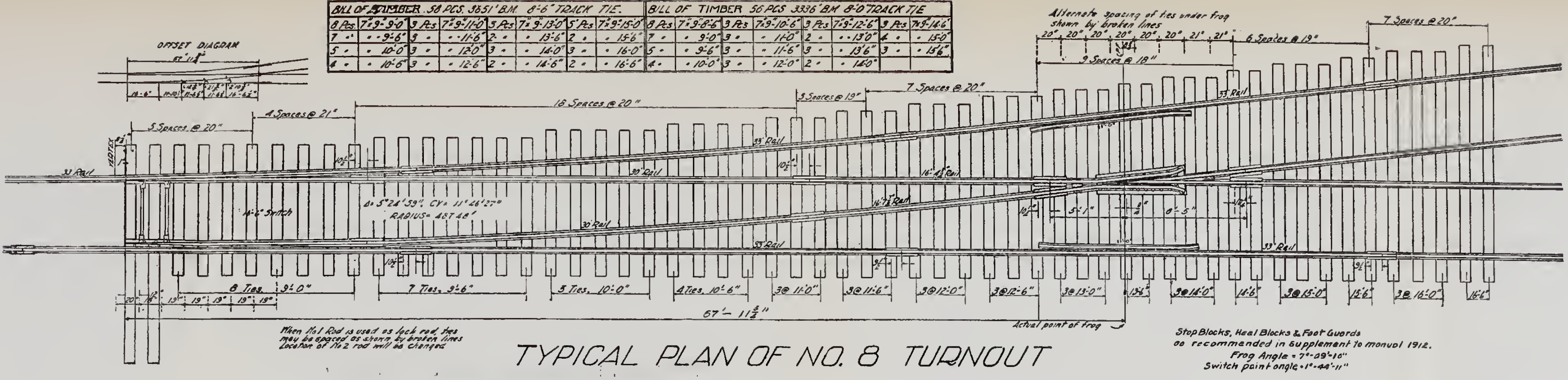
FOR SUPPORTED JOINTS USE 16 SPACES OF 19", 4 OF 22".

FOOT GUARDS AS RECOMMENDED IN SUPPLEMENT TO MANUAL 1912.

33' SWITCH

TYPICAL PLANS OF NOS. 8, 11 AND 16 TURNOUTS.

BILL OF TIMBER. 58 PCS. 3651' B.M. 8'-6" TRACK TIE.								BILL OF TIMBER 56 PCS 3336' B.M 8'-0" TRACK TIE							
8 Pcs.	7"x9"-9'-0"	3 Pcs	7"x9"-11'-0"	3 Pcs	7"x9"-13'-0"	5 Pcs	7"x9"-15'-0"	8 Pcs	7"x9"-8'-6"	3 Pcs	7"x9"-10'-6"	3 Pcs	7"x9"-12'-6"	3 Pcs	7"x9"-14'-6"
7 "	" " 9'-6"	3 "	" " 11'-6"	2 "	" 13'-6"	2 "	" 15'-6"	7 "	" 9'-0"	3 "	" 11'-0"	2 "	" " 13'-0"	4 "	" 15'-0"
5 "	" 10'-0"	3 "	" 12'-0"	3 "	" 14'-0"	3 "	" 16'-0"	5 "	" 9'-6"	3 "	" 11'-6"	3 "	" 13'-6"	3 "	" 15'-6"
4 "	" 10'-6"	3 "	" 12'-6"	2 "	" 14'-6"	2 "	" 16'-6"	4 "	" 10'-0"	3 "	" 12'-0"	2 "	" 14'-0"		

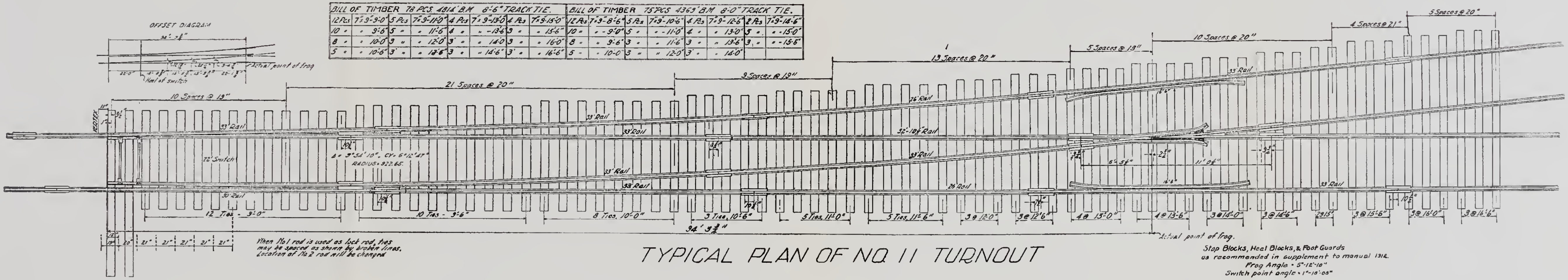


When No 1 Rod is used as lock rod, ties
may be spaced as shown by broken lines
Location of No 2 rod will be changed

Stop Blocks, Heel Blocks & Foot Guards
as recommended in supplement to manual 1912.
Frog Angle = 7°-09'-10"
Switch point angle = 1°-44'-11"

TYPICAL PLAN OF NO. 8 TURNOUT

BILL OF TIMBER 78 PCS. 4814' B.M 8'-6" TRACK TIE.								BILL OF TIMBER 75 PCS 4369' B.M 8'-0" TRACK TIE.							
12 Pcs	7"x9"-9'-0"	5 Pcs	7"x9"-11'-0"	4 Pcs	7"x9"-13'-0"	4 Pcs	7"x9"-15'-0"	12 Pcs	7"x9"-8'-6"	5 Pcs	7"x9"-10'-6"	4 Pcs	7"x9"-12'-6"	8 Pcs	7"x9"-14'-6"
10 "	" 9'-6"	5 "	" 11'-6"	4 "	" -13'-6"	3 "	" 15'-6"	10 "	" -9'-0"	5 "	" -11'-0"	4 "	" 13'-0"	5 "	" -15'-0"
8 "	" 10'-0"	3 "	" 12'-0"	3 "	" 14'-0	3 "	" 16'-0"	8 "	" 9'-6"	3 "	" 11'-6"	3 "	" 13'-6"	3 "	" -15'-6"
5 "	" 10'-6"	3 "	" 12'-6"	3 "	" 14'-6"	3 "	" 16'-6"	5 "	" 10'-0"	3 "	" 12'-0"	3 "	" 14'-0"		

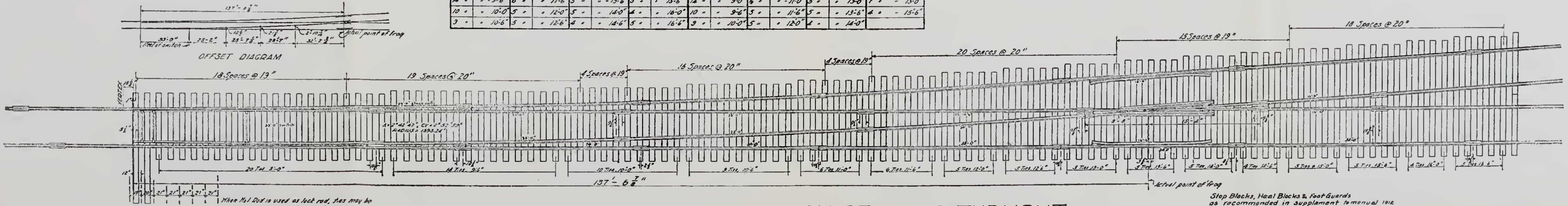


When No 1 rod is used as lock rod, ties
may be spaced as shown by broken lines.
Location of No 2 rod will be changed

Stop Blocks, Heel Blocks, & Foot Guards
as recommended in supplement to manual 1912.
Frog Angle = 5°-12'-10"
Switch point angle = 1°-10'-08"

TYPICAL PLAN OF NO. 11 TURNOUT

BILL OF TIMBER 115 PCS 7111' B.M 8'-6" TRACK TIE								BILL OF TIMBER 110 PCS. 6394' B.M 8'-0" TRACK TIE.							
20 Pcs	7"x9"-9'-0"	6 Pcs	7"x9"-11'-0"	5 Pcs	7"x9"-13'-0"	7 Pcs	7"x9"-15'-0"	20 Pcs	7"x9"-8'-6"	6 Pcs	7"x9"-10'-6"	5 Pcs	7"x9"-12'-6"	5 Pcs	7"x9"-14'-6"
14 "	" -9'-6"	6 "	" 11'-6"	5 "	" -13'-6"	5 "	" 15'-6"	14 "	" 9'-0"	6 "	" -11'-0"	5 "	" 13'-0"	7 "	" 15'-0"
10 "	" 10'-0"	5 "	" 12'-0"	5 "	" 14'-0"	4 "	" 16'-0"	10 "	" 9'-6"	5 "	" 11'-6"	5 "	" 13'-6"	4 "	" 15'-6"
9 "	" 10'-6"	5 "	" 12'-6"	4 "	" 14'-6"	5 "	" 16'-6"	9 "	" 10'-0"	5 "	" 12'-0"	4 "	" 14'-0"		



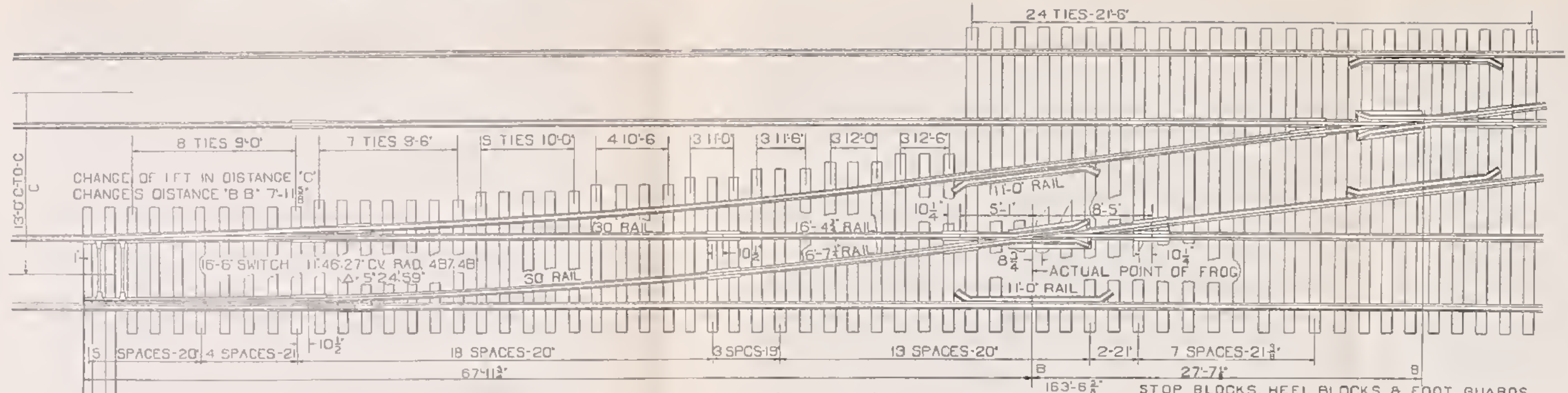
When No 1 Rod is used as lock rod, ties may be
spaced as shown by broken lines.
Location of No 2 rod will be changed.

Stop Blocks, Heel Blocks & Foot Guards
as recommended in supplement to manual 1912
Frog Angle = 3°-34'-47"
Switch point angle = 0°-52'-05"

TYPICAL PLAN OF NO. 16 TURNOUT

TYPICAL LAYOUT FOR NOS. 8, 11 AND 16 CROSSOVERS.

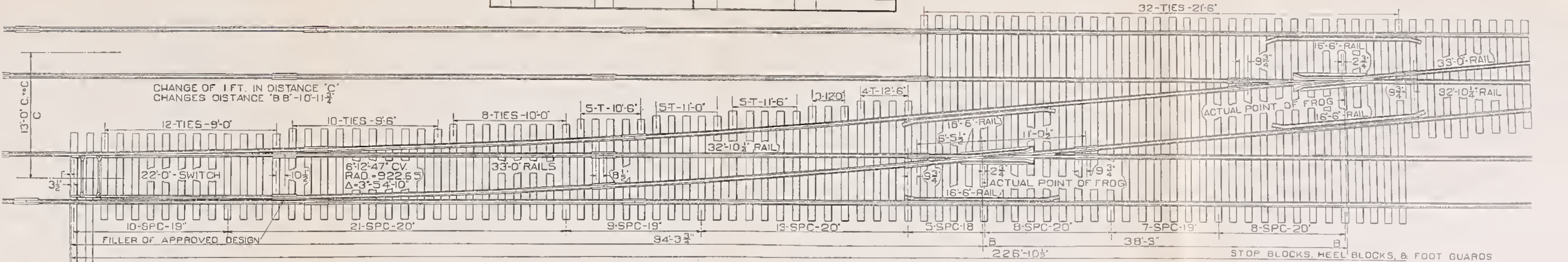
100 PCS	BILL OF TIMBER				6925' B/M.
16	TIES 7X9X 9'0"	6	TIES 7X9X11'0"	4	TIES 7X9X15'0"
14	" " 9'6"	6	" " 11'6"	24	" " 21'6"
10	" " 10'0"	6	" " 12'0"		
8	" " 10'6"	6	" " 12'6"		



TYPICAL LAYOUT OF NO 8. CROSSOVER.

STOP BLOCKS, HEEL BLOCKS & FOOT GUARDS
AS RECOMMENDED IN SUPPLEMENT TO MANUAL 1912.
FROG ANGLE = 7°-09'-10"
SWITCH POINT ANGLE = 1°-44'-11"

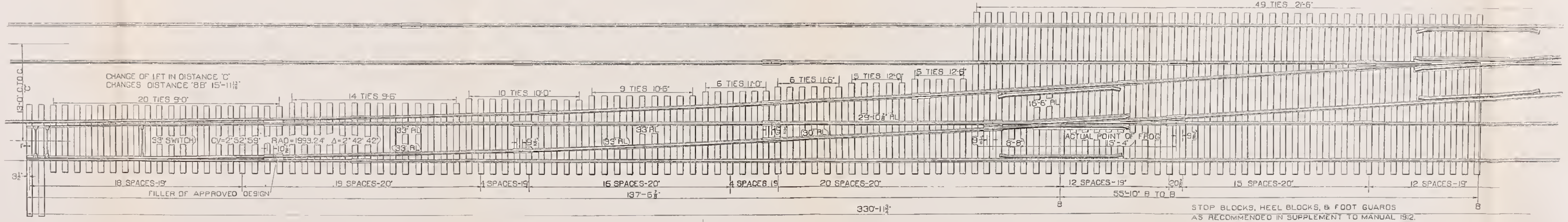
140 PIECES	BILL OF TIMBER						B/M-9534
24	TIES-7"X 9"X 9'-0"	10	TIES-7"X 9"X10'-6"	6	TIES-7"X 9"X12'-0"	32	TIES-7"X9"X 21'-6"
20	" " " 9'-6"	10	" " " 11'-0"	8	" " " 12'-6"		
16	" " " 10'-0"	10	" " " 11'-6"	4	" " " 15'-0"		



TYPICAL LAYOUT OF NO 11 CROSSOVER

STOP BLOCKS, HEEL BLOCKS, & FOOT GUARDS
AS RECOMMENDED IN SUPPLEMENT TO MANUAL 1912.
FROG ANGLE = 5°-12'-16"
SWITCH POINT ANGLE = 1°-18'-08"

BILL OF TIMBER	8'-6" TIE	203 PIECES	13878 BM		
40PCS	7x9"- 9'-0"	12 PCS	7x9"- 11'-0"	4PCS	7x9"- 15'-0"
28 "	" 9'-6"	12 "	" 11'-6"	49 "	" 21'-6"
20 "	" 10'-0"	10 "	" 12'-0"		
18 "	" 10'-6"	10 "	" 12'-6"		



TYPICAL LAYOUT OF NO 16 CROSSOVER

STOP BLOCKS, HEEL BLOCKS, & FOOT GUARDS
AS RECOMMENDED IN SUPPLEMENT TO MANUAL 1912.
FROG ANGLE = 3°-34'-47"
SWITCH POINT ANGLE = 0°-52'-05"

$\frac{1}{16}$-inch greater than the diameters of the corresponding rivets. The rivets shall be of sufficient length to provide full, neatly made heads when driven. They shall be driven tight, bringing all adjacent parts into contact.

32. Rivets, when not countersunk or flattened, shall have standard button heads of uniform size for the same size rivets. The heads shall be full and neatly made and concentric with the holes. When the rivet heads are countersunk they shall be flush with the plate and fill the holes.

Reinforcing Bars.

33. Reinforcing bars shall fit the fishing angles and web of rail throughout their length.

Plates.

34. Plates shall be flat and true to surface.

Springs.

35. Springs shall have the ends square with the axis, so that when the spring is placed on end on a flat surface it will stand perpendicular thereto.

Spring Covers.

36. Spring covers shall be of such dimensions as to permit a proper working of the springs and shall be provided with a spring bearing for each end of the spring.

Braces.

37. Braces shall fit the head and web of rail accurately.

Stops and Hold-downs.

38. Stops shall be so placed on plates as to hold the spring rail at $1\frac{7}{8}$-inch opening at the $\frac{1}{2}$-inch point. Hold-downs shall fit stops so as to allow at least 2-inch horizontal play and not more than $\frac{1}{8}$-inch vertical play.

Anti-Creeping Device.

39. The anti-creeping device shall fit accurately to the parts of the frog or angle bars.

Holes for Main Bolts.

40. Holes shall be drilled from the solid. No punching will be permitted except of bottom plates and washers. Drilling shall be accurately done, on bevel where necessary, and holes shall be made $\frac{1}{16}$-inch less in diameter than the bolt to be used. Then the parts shall be assembled and the holes reamed so they are straight and true, with no offsets

between the adjacent parts, and of such size as to give the bolts a driving fit for their entire length.

41. In lieu of the above specification for drilling and reaming, the manufacturer may assemble and accurately fit all the parts, before any drilling whatever is done; after the parts are securely clamped in their correct positions the holes may be drilled of such a size as to give the bolts a driving fit for their entire length.

Marking.

42. The number of the frog, maker's name, weight of rail and the date shall be plainly stamped with ¾-inch figures and letters on the flare of one wing rail for rigid frogs and the flare of both wing rails for spring frogs, or a plate shall be fastened to the frog with the same information.

SWITCHES.

Throw.

43. 5 inches at center line of No. 1 rod.

Gage of Track.

44. 4 feet 8½ inches.

Switch Rails.

45. Side planing and bending shall conform to a spread at the heel of 6¼ inches between the gage lines of the stock rail and the switch rail and a thickness of ¼-inch at the point. The bending and planing shall be done so as to give a straight gage line to the switch rail. The switch rail shall afterward be ground down to a thickness of ⅛-inch at the point, beginning 2 feet back from the point of the switch; the point of the switch shall then be ground down to a sharp edge with a radius of 1½ inches. The head of switch rail shall fit neatly against the head of stock rail from point of switch rail to point of divergence. The inner edge of the head of the stock rail and the outer face of the web of the switch rail at the point shall be in the same vertical line when the switch rail is fitted against the stock rail.

46. Top planing shall conform to the measurements shown on Fig. 1 and Table 1.

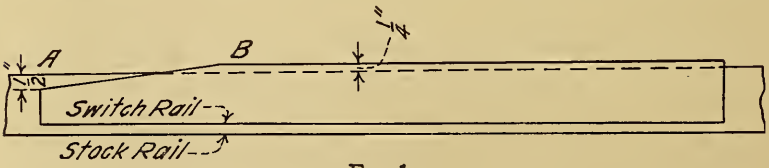


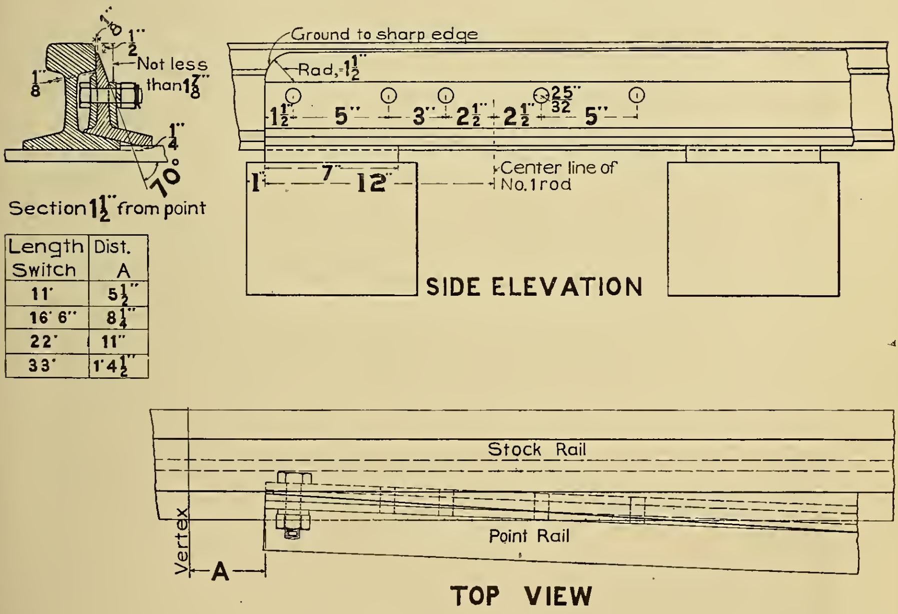
Fig. 1.

TABLE 1.

Switch	A B
33 feet	12 feet
22 feet	9 feet
16 feet 6 inches	7 feet
11 feet	5 feet

47. Bottom of switch rail shall be planed to fit neatly on base of stock rail where bases overlap.

48. The point of switch rail shall be as shown by Fig. 2.



Length Switch	Dist. A
11'	$5\frac{1}{2}$"
16' 6"	$8\frac{1}{4}$"
22'	11"
33'	1' $4\frac{1}{2}$"

FIG. 2. DETAILS OF POINTS.

49. Holes for switch rod lugs and stop blocks shall be $\frac{25}{32}$-inch in diameter and 5 inches center to center. Holes for reinforcing bars shall be $\frac{25}{32}$-inch diameter. Number and location as provided under Reinforcing Bars.

Lugs.

50. Lugs shall be as deep as the section of rail will permit.

51. Distance between centers of holes for bolts running through the web of the rail shall be 5 inches. Diameter of holes shall be $\frac{25}{32}$-inch. Switch rod bolt hole shall be $1\frac{1}{32}$ inches in diameter.

Switch Rods.

52. Switch rods shall be ¾ by 2½ inches and shall be held in a horizontal plane. Bolt holes shall be $1\frac{1}{32}$ inches in diameter. There shall be at least 1½ inches of metal at end beyond bolt holes.

Reinforcing Bars.

53. A reinforcing bar ⅜-inch thick shall be riveted to each side of each switch rail and point ends shall be made flush with point of switch rail. The bars shall be as long as the heel connections will permit. Bars shall fit against web of rail and shall fill the space between head and flange of rail. There shall be ⅛-inch clearance between outer bar and head of stock rail where the bar projects under the head of stock rail. Top of inner bar, where it projects beyond the head of switch rail, shall not be less than 1⅞ inches below the top of stock rail. The reinforcing bar shall be beveled to an angle of 45 degrees where it projects beyond the head of the rail.

54. Bars shall be fastened to rail with ¾-inch *rivets,* *bolts,* except that at the first, second and fifth holes, and the holes through which the lugs are fastened, they shall be bolted. Center of first hole shall be 1½ inches from point and center of last hole in bar shall be 2 inches from heel end of bar. Intermediate *rivets* *bolts* shall be spaced so that there shall be fastenings at intervals not greater than 12 inches.

Stop Blocks.

55. Stop blocks shall be of approved design with holes $\frac{13}{16}$-inch in diameter. Stop blocks shall be spaced as nearly as practicable at equal intervals between the end of planing and heel of switch.

Heel Blocks.

56. Heel blocks shall be of approved design with standard rail drilling.

Bolts and Nuts.

57. Bolts fastening lugs, stop blocks and foot-guards to switch rails shall be ¾-inch in diameter. Bolts connecting the lugs with switch rods and the switchstand connecting bolt shall be 1 inch in diameter and machine turned. All bolts shall be provided with nutlocks and cotters. ¾-inch bolts shall have hexagonal nuts and 1-inch bolts shall have square nuts.

Rivets.

58. The diameters of the rivets shall be of full size shown on plan, and the diameters of the rivet holes shall be not more than $\frac{1}{16}$-inch greater than the diameters of the corresponding rivets. The rivets shall

be of sufficient length to provide full, neatly made heads when driven. They shall be driven tight, bringing all adjacent parts into contact.

59. Rivets, when not countersunk or flattened, shall have standard button heads of uniform size for the same size rivets. The heads shall be full and neatly made and concentric with the holes.

60. When the rivet heads are countersunk they shall be flush with the plate and fill the holes.

Plates.

61. There shall be on each tie two plates of suitable length ⅞-inch by 7-inch, planed down to receive the stock rail and braces. Three holes outside and two inside are required for ⅞-inch lag screws or screw spikes, or for ordinary spikes, as may be specified, on all switch ties, except the two head ties, where there shall be three outside and five inside, one of the inside holes to be in position for spiking the switch.

Braces.

62. Braces shall be of such a design that 2½-inch clearance for detector bars may be obtained. Three holes for ⅞-inch lag screws or screw spikes shall be provided.

Foot Guards.

63. Strap foot-guards shall have a minimum thickness of ⅜-inch and shall be fastened to the web of the rail by ¾-inch bolts or rivets.

[29] TURNOUTS.

NOTATION.

G = Gage of track.
N = Frog number.
F = Frog angle.
W = $\overline{PT_1}$ = $\overline{PT_2}$ = Length from theoretical point of frog to toe of frog.
K = Length from theoretical point of frog to heel of frog.
S = $\overline{AC}$ = Length of switch rail.
H = $\overline{CZ}$ = Heel distance.
μ = Angle $\overline{COE_1}$ = Subtended angle from heel of switch to any point on the gage side of the outer rail of lead curve.
t = Thickness of frog point.
t′ = Thickness of switch point.
P = Theoretical point of frog.
T_1, T_2 = Toe of frog.
B = Foot of perpendicular from theoretical point of frog upon gage side of opposite main-track rail.
A = Actual point of switch rail.
C = Heel of switch rail.
Z = Foot of perpendicular from gage side of switch rail at heel upon gage side of main-track rail.
O = Center of lead curve.
a = Angle $\overline{CAZ}$ = Switch angle.
L = $\overline{AB}$ = Lead distance measured along center line of main track from actual point of switch to theoretical point of frog.
L′ = Lead distance measured along center line of main track from actual point of switch to actual point of frog.
R = Radius of center line of lead curve.
D = Degree of lead curve on center line.
CC = $\overline{CE_1ET_2}$ = Closure of curved rail, or arc of outer rail of lead curve.
CS = $\overline{Z_1T_1}$ = Closure of straight rail, or length of straight rail in lead from heel of switch to toe of frog.
Y = Perpendicular offset from any point on the curved lead rail to the main-track rail.
X = Distance from foot of such offset to point of switch rail.

FORMULAS.

$$a = \sin^{-1}\left(\frac{H - t'}{S}\right) \qquad \text{(1)}$$

$$L = (S - W)\,\frac{\sin \frac{1}{2}(F - a)}{\sin \frac{1}{2}(F + a)} + (G - t')\cot \tfrac{1}{2}(F + a) \qquad \text{(4)}$$

$$R = \frac{G - H - W \sin F}{2 \cdot \sin \frac{1}{2}(F - a) \cdot \sin \frac{1}{2}(F + a)} - \frac{G}{2} \qquad \text{(6)}$$

$$R = \frac{G - H - W \cdot \sin F}{\cos a - \cos F} - \frac{G}{2} \qquad \text{(7)}$$

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[29] Adopted, Vol. 10, Part 1, 1909, pp. 402-407, 451-461; Vol. 11, Part 2, 1910, pp. 940, 941, 952-954; Vol. 16, 1915, pp. 730, 1145.

$$D = 2 \cdot \sin^{-1}\left(\frac{50}{R}\right) \quad \ldots\ldots (8)$$

$$CC = 0.017453 \cdot \left(R + \frac{G}{2}\right) \cdot (F\text{-}a) \quad \ldots\ldots (9)$$

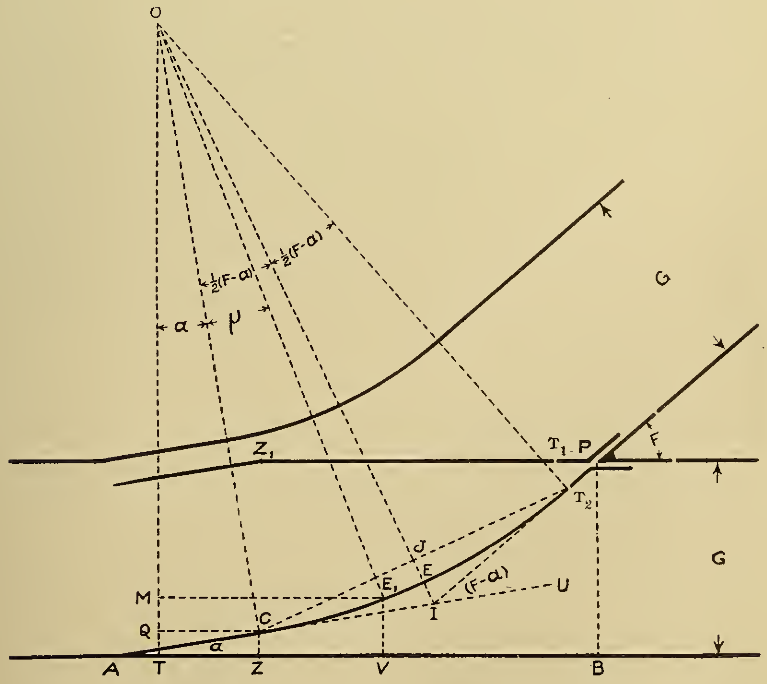
$$CS = L - (W + S) \quad \ldots\ldots (10)$$

$$Y = H + \left(R + \frac{G}{2}\right) \cdot \cos a - \left(R + \frac{G}{2}\right) \cdot \cos(\mu + a) \quad \ldots\ldots (11)$$

$$X = S - \left(R + \frac{G}{2}\right) \cdot \sin a + \left(R + \frac{G}{2}\right) \cdot \sin(\mu + a) \quad \ldots\ldots (12)$$

$$L' = L + Nt \quad \ldots\ldots (13)$$

In (9), (F-a) is expressed in degrees and decimals of a degree. In (11) and (12) it is recommended that the value of X and Y be obtained for at least three values of μ, namely, $\mu = ¼$ (F-a), $\mu = ½$ (F-a) and $\mu = ¾$ (F-a).



In all cases Gage is considered 4 ft. 8½ in.

[30] TABLE OF THEORETICAL AND PRACTICAL SWITCH LEADS.

PROPERTIES OF FROGS. Thickness of All Frog Points 0½"												Properties of Switches. For All Switches Thickness of Point=0¼" and Heel Distance =H=6¼"					THEORETICAL LEADS							
N=Frog Number.	F=Frog Angle.			W=Length Theoretical Point to Toe.		K=Length Theoretical Point to Heel.		Total Length.		Spread at Toe.	Spread at Heel.	S=Length of Switch Rail.		a=Switch Angle.			R=Radius of Center Line.	D=Degree of Lead Curve.			Distance Point of Switch Rail to Theoretical Point of Frog.	Closure Straight Rail.	Closure Curved Rail.
I	II			III		IV		V		VI	VII	VIII		IX			X	XI			XII	XIII	XIV
	Deg.	Min.	Sec.	Ft.	In.	Ft.	In.	Ft.	In.	Feet	Feet	Ft.	In.	Deg.	Min.	Sec.	Feet	Deg.	Min.	Sec.	Feet	Feet	Feet
4	14	15	00	3	2	5	4	8	6	0 79	1 32	11	0	2	36	19	112.26	52	53	56	37.05	22.88	23.29
5	11	25	16	3	7	6	5	10	0	0 71	1 28	11	0	2	36	19	183.22	31	40	24	42.77	28.19	28.55
6	9	31	38	4	0	7	0	11	0	0.66	1.16	11	0	2	36	19	273.95	21	01	58	48.11	33.11	33.38
7	8	10	16	4	5	8	1	12	6	0 63	1.15	16	6	1	44	11	364.88	15	47	19	61.94	41.02	41.24
8	7	09	10	4	9	8	9	13	6	0.59	1.09	16	6	1	44	11	488.71	11	44	40	67.47	46.22	46.42
9	6	21	35	6	0	10	0	16	0	0.67	1.11	16	6	1	44	11	616.27	9	18	27	72.24	49.74	49.92
9½	6	01	32	6	0	10	0	16	0	0.63	1.05	16	6	1	44	11	699.97	8	11	33	74.90	52.40	52.58
10	5	43	29	6	0	10	6	16	6	0 60	1 05	16	6	1	44	11	790.25	7	15	18	77.51	55.01	55.17
11	5	12	18	6	0	11	6	17	6	0.54	1.05	22	0	1	18	8	940 21	6	05	48	92.06	64.06	64.20
12	4	46	19	6	5	12	1	18	6	0.53	1 01	22	0	1	18	8	1136.34	5	02	38	97.25	68.83	68.96
15	3	49	06	7	8	14	10	22	6	0 51	0.99	33	0	0	52	5	1744.45	3	17	06	130.50	89.83	89.94
16	3	34	47	8	0	16	0	24	0	0.50	1 00	33	0	0	52	5	2005.98	2	51	24	135.95	94.95	95.05
18	3	10	56	8	10	17	8	26	6	0 49	0 98	33	0	0	52	5	2587 66	2	12	52	146.38	104.54	104 61
20	2	51	51	9	8	19	4	29	0	0 48	0.97	33	0	0	52	5	3262.98	1	45	22	156.35	113.68	113.76
24	2	23	13	11	4	23	2	34	6	0.47	0.97	33	0	0	52	5	4932 77	1	09	42	175.09	130.66	130.77

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[30] Adopted, Vol. 14, 1913, pp. 131, 1059; Vol. 15, 1914, pp. 593, 594, 1063.

In all cases Gage is considered 4 ft. 8½ in.

TABLE OF THEORETICAL AND PRACTICAL SWITCH LEADS.

PRACTICAL LEADS

N=Frog Number.	R₁=Radius of Center Line.	D₁=Degree of Lead Curve on Center Line.			Rectangular Co-ordinates to the Quarter and Center Points on Gage Side of Curved Rail, Referred to Point of Switch Rail as Origin.						T_s=Tangent Adjacent to Switch Rail.	T_f=Tangent Adjacent to Toe of Frog.	L₁=Distance Actual Point of Switch Rail to Theoretical Point of Frog.	Lead=Distance Actual Point of Switch Rail to Actual Point of Frog.	Closure for Straight Rail.		Closure for Curved Rail.	
					X	X₁	X₂	Y	Y₁	Y₂								
I	XV	XVI			XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	XXVI	XXVII		XXVIII	
	Feet	Deg.	Min.	Sec.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet				
4	110.69	53	42	24	17.74	23.44	29.75	0.97	1.67	2.79	1.03	0.00	37.77	37.94	1-23.60		1-24	
5	174.34	33	19	57	17.78	24.54	31.27	0.95	1.61	2.62	0.00	0.82	42.26	42.47	1-27.68		1-28	
6	265.39	21	43	04	19.07	27.13	35.15	1.01	1.74	2.72	0.00	0.66	47.73	47.98	1-32.73		1-33	
7	362.08	15	52	29	26.72	36.93	47.11	0.97	1.71	2.74	0.00	0.19	61.81	62.10	1-13.89	1-27	1-14.11	1-27
8	487.48	11	46	27	28.37	39.91	51.45	1.02	1.78	2.91	0.30	0.00	67.65	67.98	1-16.40	1-30	1-16.60	1-30
9	605.18	9	28	42	28.75	40.98	53.19	1.02	1.76	2.75	0.00	0.57	71.91	72.28	1-16.41	1-33	1-16.59	1-33
9½	695.45	8	14	45	30.31	43.35	56.37	1.06	1.82	2.83	0.76	0.00	75.32	75.71	1-25.82	1-27	1-26	1-27
10	790.25	7	15	18	30.28	44.05	57.81	1.06	1.84	2.85	0.00	0.00	77.51	77.93	1-27	1-28	1-27.17	1-28
11	922.65	6	12	47	40.74	56.47	72.19	1.08	1.84	2.87	2.99	0.00	93.85	94.31	1-32.85	1-33	2-33	
12	1098.73	5	12	59	43.99	60.65	77.28	1.15	1.90	2.91	5.33	0.00	100.30	100.80	1-23.88	2-24	3-24	
15	1743.80	3	17	10	55.49	77.98	100.45	1.01	1.78	2.84	0.09	0.00	130.56	131.19	2-30	1-29.89	3-30	
16	1993.24	2	52	29	58.16	81.76	105.35	1.04	1.82	2.87	1.56	0.00	136.90	137.57	1-29.90	2-33	1-30	2-33
18	2546.31	2	14	31	58.73	84.46	110.10	1.04	1.82	2.86	0.00	1.08	145.76	146.51	1-25.93	3-26	4-26	
20	3257.26	1	45	32	61.84	90.21	118.59	1.08	1.88	2.93	0.44	0.00	156.59	157.42	1-26.92	2-27 1-33	3-27	1-33
24	4886.16	1	10	21	67.82	100.21	132.59	1.27	1.97	3.00	2.43	0.00	176.22	177.22	1-32.89	3-33	4-33	

[31] MAIN LINE TURNOUTS.

Typical plans illustrating recommended designs for Nos. 8, 11 and 16 main line turnouts, as representing good practice, are shown on the inserts.

[32] CROSSOVERS.

Typical plans of Nos. 8, 11 and 16 crossovers, as representing good practice, are shown on the inserts.

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[31] Adopted, Vol. 14, 1913, pp. 108, 130, 1058.
[32] Adopted, Vol. 15, 1914, pp. 594, 1063.

COMMITTEE VI.

BUILDINGS.

[1]PASSENGER STATIONS WITH ONE GENERAL WAITING ROOM.

The use of one general waiting room for a passenger station (without reference to separate waiting rooms for colored people) is recommended as good practice for the following reasons:

(1) It permits the general waiting room to be properly proportioned.

(2) It permits proper development of a retiring room for women, with private entrance to the lavatory.

(3) It readily admits of the other rooms being properly proportioned.

(4) It permits ease of access from the agent's office to the trains, to the baggage room and to the waiting room.

(5) It permits the ticket office to be of proper size and location for general office purposes.

(6) It admits of the station being contracted in size without detriment to facilities.

(7) It offers economy in heating.

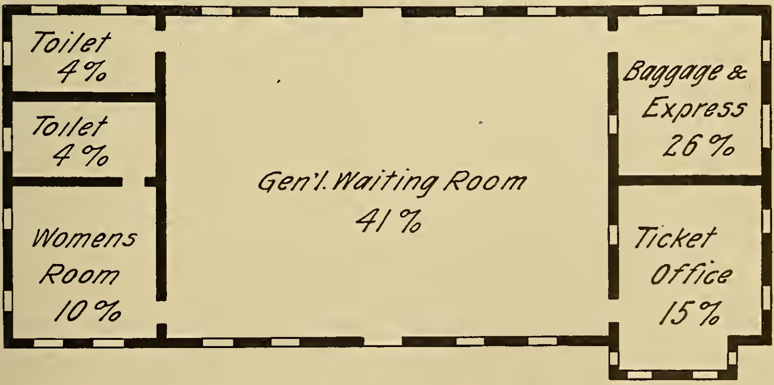

Fig. 1. Division of Floor Area Recommended for Passenger Stations with One General Waiting Room.

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[1] Adopted, Vol. 6, 1905, pp. 682-684, 690; Vol. 11, Part 2, 1910, pp. 1022, 1023, 1049; Vol. 16, 1915, pp. 739, 1149.

[2]ENGINE HOUSE DESIGN.

(Applicable to New Houses.)

Form.

(a) The circular form is preferable.

(b) At points where not more than three or four locomotives are housed at one time, and where it is more economical to provide a "Y" track than a turntable, or where it is not necessary to turn locomotives, a rectangular house, either with through tracks or with switches at one end only, may be desirable.

(c) At shops where a transfer table is used, a rectangular engine house served by the transfer table may be desirable.

Turntable.

(a) The turntable should be long enough to balance the engine when the tender is empty.

(b) A deck turntable is preferable to a through table.

(c) At important terminals, turntables are most economically operated by mechanical means. Where few and light engines are turned, hand operation may be desirable.

Where electric power can be obtained at a reasonable cost, an electric tractor is the most efficient means for operating a turntable, the cost of power is cheaper, and it is superior in continuity of service and maintenance. The first cost is approximatey the same as an air motor of equal power and size.

Power wires are brought to the table by either the overhead or the underground method. Overhead device has the advantage of accessibility for inspection and repair. Special care must be taken to properly protect collector head from weather and gases and support collector rigidly (framework supporting same should be fastened to steel frame of table and not to ties, and must be securely braced) ; the wires should be large enough to keep them from breaking from sleet and should be supported to framework supporting collector. Any play at table multiplies at collector head. Wires should be brought to pole, close to curb of turntable, keeping lines as far distant from nearest wall of roundhouse as possible, to minimize the danger of destruction by fire.

When the underground system is properly installed, its advantages are that all exposed, non-current carrying parts are permanently grounded, including the circular-track rail (the only part of system to repair is collector head); non-interference from weather if turntable pit is properly drained.

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[2] Adopted, Vol. 6, 1905, pp. 684-686, 690-696; Vol. 7, 1906, pp. 630, 638; Vol. 10, Part 2, 1909, pp. 1123, 1124, 1132-1136; Vol. 11, Part 2, 1910, pp. 1022, 1024-1026, 1049-1054; Vol. 16, 1915, pp. 740, 1149.

The disadvantages are: the wire is not so easily repaired, and is much more difficult to originally install, as they must be properly protected from water, and cannot be successfully laid in a fill or on ground where settlement or shifting takes place. Where turntable pit cannot be well drained, it cannot be used with success. It has the advantage of protecting power to run table in case of fire to roundhouse, especially in one of a nearly complete circle.

Compressed air tractors are frequently used.

Ordinarily the power costs much more than electricity and is not so reliable. At points having no power plant the locomotive to be turned furnishes the compressed air; in this case an auxiliary supply should be maintained by providing small air tank secured to the turntable for operating it before or after the engine is placed.

(d) The deck on turntable should be wide enough to provide a walk on each side and be protected with hand rails.

Turntable Pit.

(a) The turntable pit should be well drained and preferably paved.

(b) The circle wall should be of concrete or brick, with proper supports and fastenings for rails on the coping.

(c) The circle rail should preferably bear directly on concrete base. The use of wood ties and tie plates supported by masonry is desirable under some conditions.

(d) Easy access to the parts of a turntable for the oiling of bearings, painting and inspection should be provided in the design of the turntable pit, unless ample provision is made in the turntable itself.

Door Openings.

The clear opening of entrance doors should not be less than thirteen (13) feet in width and sixteen (16) feet in height.

Doors.

Doors should be easily operated, fit snugly, be easily repaired and maintained, and should admit of the use of small doors.

Tracks.

(a) Lead tracks to the turntable should line up with tracks of the engine house where possible.

(b) Tracks should be on a level grade and should be provided with stop blocks.

(c) Special fastenings of the track rails at the circle wall and on the turntable are desirable to prevent movement of the rails, to give good bearing and to lessen the damage from derailed wheels.

Position of Locomotive.

In a circular house the locomotive should stand normally with the tender toward the turntable.

Length of House.

The length of stall along center line of track should be at least fifteen (15) feet greater than the over-all length of the locomotive, to provide a walkway behind the tender, a trucking space in front of the pilot and a certain distance in which to stop the locomotive or to move it to bring side rods or other parts into convenient positions.

Materials.

(a) The material used in construction of the house should be non-corrosive, unless proper care be taken to prevent corrosion.

(b) The additional security against interruption to traffic from fire warrants serious consideration of the use of a fireproof roof, and dividing the engine house into units of approximately 10 stalls by the use of division walls built of fireproof material.

(c) When the roof is of reinforced concrete the columns and roof-beams should be of the same material.

(d) Reinforced concrete should be used for the walls only where special conditions reduce its cost below that of brick or plain concrete, and should not be used for that portion of the wall diretly in line of track where engine is liable to run into it.

Engine Pits.

Engine pits should be not less than 60 feet in length, with convex floor, with drainage toward the turntable. The walls and floors may be of concrete. Proper provision should be made for the support of the jacking timbers.

Smoke Jacks.

The smoke jacks should be fixed. The bottom opening should be not less than forty-two (42) inches wide, and long enough to receive the smoke from the stack at its limiting positions, due to the adjustment of the driving wheels to bring the side rods in proper position for repairs. The bottom of the jack should be as low as the engines will allow, and it should be furnished with a drip trough. The slope upward should be gradual to the flue. The area of the cross-section of the flue should be not less than seven (7) square feet, and the jack should be made of non-combustible material. (This design of jack applies to all houses where regulations will permit. In some cities, where smoke abatement laws are in force, special design of jacks are necessary.)

Floors.

The floor should be of permanent construction. It should be crowned between pits.

Drop Pits.

Drop pits should be provided for handling truck, driving and trailer wheels.

Heating.

(a) Heat should be concentrated at the pits.

(b) The general temperature of the engine house should be kept between 50 and 60 degrees.

(c) The recommended method for heating is by hot air driven by fans through permanent ducts, which should be under the floor where practicable. The outlets should be fitted with dampers so that heat can be cut off while men are working in the pit. The fresh air supply should be taken from the exterior of the building and no recirculation allowed. It should be delivered to the pits under the engine portion of the locomotive. It should be heated as far as possible by exhaust steam, supplemented, as required, by live steam.

Window Lights.

(a) The disadvantages of skylights are so much greater than their advantages as to make them undesirable.

(b) Windows in the outer walls should be made as large as practicable with the largest glass or light area consistent with the requisite strength. In general, the lower sill should be not more than four feet from the floor, and only sufficient space left between pilasters and sides of window frames and girders and window heads to properly secure the window frames. Windows or transoms as large as practicable should be provided over all doors where locomotives enter. Window lights in doors are objectionable on account of difficulty of maintenance.

Electric Lighting.

General distribution of illumination should be provided between pits by arranging a number of lights to avoid shadows and to give good light for workmen at the sides of the locomotives. There should be plugged outlets for incandescent lamps in each alternate space between pits.

Piping.

(a) The engine house should be equipped with piping for air, steam and water supply, and where desired, piping for a washout and refilling system should be installed. Where this system is installed, the blowoff lines should be led to a central reservoir; where it is not used, the blowoff lines should be led outside the house.

(b) The steam outlet should be located near the front end of the boiler. The blowoff pipe, the air, the washout and refilling water and the cold-water connections should be near the front end of the firebox. Connections need only be provided in alternate space between stalls.

Tools.

There should ordinarily be facilities provided for hand tools and for the location of a few machine tools, preferably electrically driven.

Hoists.

Hoists with differential blocks are generally used for handling heavy repair parts, and suitable provision should be provided for supporting them.

[3]LOCOMOTIVE COALING STATIONS.

(1) To properly compare the relative economy of locomotive coaling stations, the cost per ton of handling coal should include charges for interest and depreciation on the investment, charges for maintenance and operation and a charge for the cost of such actual storage as is required in the daily operation of the coaling station itself. The additional seasonal storage required in certain parts of the country to be considered as a separate proposition. Most of these charges are included in accounts prescribed by the Interstate Commerce Commission in the "Issue of 1914," effective July 1, 1914. The classification of "Investment in Road and Equipment" shows an account, "Fuel Stations," covering all the investment except the cost of required tracks and right-of-way. The classification of "Operating Expenses" prescribes an account, "Fuel Stations," covering essentially repairs to coaling stations; an account, "Fuel Station Depreciation," permitting charges for estimated depreciation, and accounts "Fuel for Yard Locomotives" and "Fuel for Train Locomotives," which include in the cost of fuel all the costs of operation of the plant itself. These prescribed accounts do not include the cost of switching cars onto trestle or coaling tracks, nor the cost

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[3] Adopted, Vol. 8, 1907, pp. 268, 286; Vol. 9, 1908, pp. 163-166, 173, 183-200; Vol. 11, Part 2, 1910, pp. 1027, 1054; Vol. 16, 1915, pp. 743, 1149.

of using cars for storage purposes, all of which should be included in figuring the cost per ton of handling coal.

(2) Provision should be made for fire protection, the avoidance of damage to the coal and its delivery in the best possible condition.

(3) The use of self-clearing cars should be made possible, and ordinarily it should also be possible to shovel from flat-bottomed cars.

(4) Storage for emergency purposes and fireproof construction are, in general, to be recommended. In some cases duplicate machinery is desirable.

(5) It is not possible to give absolute limits between which different types of coaling arrangements are recommended for use. Each installation must be considered as an individual problem. Before the selection of a type of coaling station can be based upon the least cost per ton of handling coal, consideration must be given to the extent to which investments in permanent structures and the adoption of fixed track arrangements are warranted, and consideration should be given to price of materials, cost and character of labor, possible track arrangements, amount of coal desired, fire protection, power and attendance and shifting service available and the cost of maintenance.

(a) Where the quantity of coal handled is small, particularly at terminal points where locomotives lie over night, it is recommended that the locomotives be coaled either directly from cars or by handling from cars to an elevated platform provided with a jib crane and one-ton buckets, and from these buckets to the locomotive.

(b) A locomotive crane with suitable buckets is desirable at terminals under certain conditions, particularly where other work can be economically performed by the locomotive crane.

(c) For terminals larger than those previously described, the type of coaling station which should be selected as most desirable is dependent entirely upon local conditions. Where it is required that coal be delivered to not more than two tracks, and where the necessary ground space is available, a coaling station of the trestle or gravity type, with approximately five (5) per cent. incline approach, where coal in cars is placed on top of the trestle by locomotives, the coal being stored in bins from where it is placed on the locomotives by gravity, is recommended. Where it is required to deliver coal to more than two tracks, or where the ground space for a trestle type is not available, a mechanical type is recommended.

[4]OIL HOUSES.

(1) Oil houses at terminals should be separated from other buildings.

(2) Oil houses should be fireproof and the storage in large houses should preferably be either underground or in the basement.

(3) Oils that are stored in sufficient quantities should be delivered to the tanks in the house direct from tank cars. For oils that are stored only in small quantities, provision should be made for delivery to storage tanks from barrels by pipes through the floor.

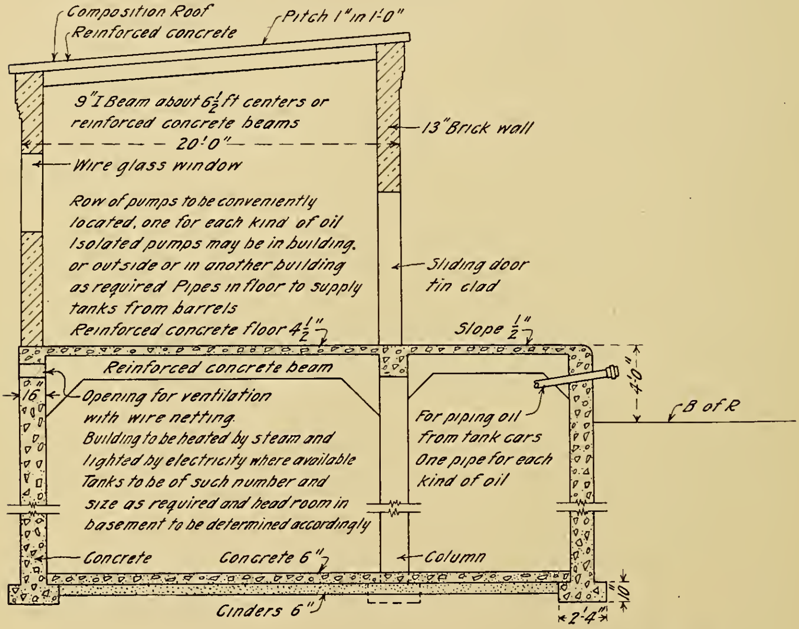
Composition Roof
Reinforced concrete
Pitch 1" in 1'-0"
9" I Beam about 6½ ft centers or reinforced concrete beams
20'-0"
13" Brick wall
Wire glass window
Row of pumps to be conveniently located, one for each kind of oil
Isolated pumps may be in building, or outside or in another building as required Pipes in floor to supply tanks from barrels
Reinforced concrete floor 4½"
Sliding door tin clad
Slope ½"
4'-0"
B of R
Reinforced concrete beam
16"
Opening for ventilation with wire netting
Building to be heated by steam and lighted by electricity where available
Tanks to be of such number and size as required and head room in basement to be determined accordingly
For piping oil from tank cars
One pipe for each kind of oil
Concrete
Concrete 6"
Column
Cinders 6"
10"
2'-4"

FIG. 2. CROSS-SECTION OF TYPICAL OIL HOUSE, 20 BY 40 FEET.

(4) The delivery system from the storage tanks to the faucets should be such that the oil can be delivered quickly and measured automatically. The delivery should also be such that there will be a minimum of dripping at the faucet and that the dripping may drain back to the storage tanks.

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[4] Adopted, Vol. 10, 1909, pp. 1127, 1128, 1136-1140; Vol. 11, Part 2, 1910, pp. 1027, 1037, 1054; Vol. 16, 1915, pp. 745, 1149.

(5) Openings for ventilation should be provided above the level of the top of the tanks.

(6) Lighting, when required, should be by electricity and heating by steam.

(7) For fire protection purposes a live-steam line should be run to the oil storage space, controlled by a valve outside the house.

[5]SECTION TOOL HOUSE.

Class A.

House, 14 by 20 feet, with long dimension parallel to track; house to have sliding door 8 feet in clear at extreme end on track side to permit the storing of handcar.

Class B.

House, 12 by 18 feet, with long dimension parallel to the track; house to have sliding door 8 feet in clear at extreme end of track side to permit the storing of handcar.

Class C.

House, 10 by 14 feet, with the short dimension parallel to the track, with double swinging doors, swinging out on the end nearest the track.

Building to be on wooden posts, unless the location can be permanent, in which case brick or concrete piers may be substituted.

[6]ROOFINGS.

In selecting roofing there should be considered:

(1) Chance of leaks due to character of construction.

(2) Probable life, including chance of damage by the elements and by wear from other causes.

(3) Fire-resisting value.

(4) Cost of maintenance.

(5) First cost.

The important materials may be classified as follows:

Bituminous substances, applied with felts made of rags, asbestos or jute.

Clay and cement products and slate.

Metals.

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[5] Adopted, Vol. 11, Part 2, 1910, pp. 1044-1046, 1054; Vol. 16, 1915, pp. 746, 1149.

[6] Adopted, Vol. 12, Part 1, 1911, pp. 588, 623; Vol. 14, 1913, pp. 839, 1084; Vol. 15, 1914, pp. 705-709, 1099; Vol. 16, 1915, pp. 746, 1149.

They are laid in two general types—that for a flat roof, cemented together, as a coal-tar pitch-and-gravel roof or as an ordinary tin roof, and that for a steep roof, laid shingle fashion.

Bituminous Materials.

The common bituminous materials are:

Coal-tar pitch (the heavier distillates of bituminous coal).
Various asphalts (bitumens found naturally in the solid state).
Various petroleum products.
Various animal and vegetable residue.

Values.

Their peculiar value lies in the fact that they are practically insoluble in water; that they are elastic, adhesive and comparatively stable.

Coal-Tar Pitch.

Coal-tar pitch is easily affected by heat and cold, is not acted upon at all by water, is easily worked, and if properly protected is very stable. It should ordinarily be used as it comes from the still, "straight run," of a consistency suitable to the climate and to proper application.

Water Gas-Tar Pitch.

Water gas-tar pitch, a by-product in the manufacture of water gas, which is enriched by gas from petroleum oils, resembles coal-tar. It is inferior to coal-tar for roofing purposes, and materials made from it should only be accepted in the low-priced products. It has more value as a saturant of felts than as a coating.

Asphalts.

The asphalts are unsuitable for use in their natural state. They are ordinarily fluxed with products of petroleum.

Petroleums.

The petroleums found in this country vary considerably, and grade roughly in quality, according to location from East to West. The California oils, with their asphaltic base, furnish materials especially valuable for roofing.

Blown Oils.

The blowing of air through a heated still of certain petroleum products produces "blown oils," which, while somewhat lacking in adhesive properties, are not easily susceptible to atmospheric changes and are valuable especially for roofing coatings.

Combinations.

A single asphalt fluxed with a single oil is for most purposes a crude and unsatisfactory material. To secure the best results for any desired purpose, several oil and asphaltic substances must ordinarily be compounded. This requires skill and experience. Those properly made are for certain conditions invaluable, particularly for ready roofing, for which tar products are not suited.

The asphalt and petroleum products are not so readily affected by heat and cold as is coal-tar pitch, and lesser amounts of them are necessary to get good results. They are more expensive, require more skill in handling, and, when protected, some at least are to some extent liable to lose their life by drying out of the oil fluxes. Unprotected, they do much better than does coal-tar.

FELTS.

The bituminous substances are used with felts whose qualities considerably affect the roofing. The ordinary felt is made of rags, mainly cotton. "Wool felt" is a misnomer. Asbestos felts, as compared with the rag felt, act less as a carrying medium for the bitumens, but rather as a protection to the layers of bitumen. They are not suited for use with coal-tar pitch, but are not injured by hot asphalt. They are more expensive than rag felts, but have some peculiar and valuable qualities. Burlap made from jute decays easily when not protected. It is used in a few ready roofings with rag felts to increase their tensile strength, the need of which is not generally agreed to.

BUILT-UP ROOFS.

The bituminous roofings come ready to lay, or can be built up on the roof, using layers of saturated felt, mopped with pitch and properly protected.

The built-up roof is especially valuable for flat surfaces. It can be made as heavy as desired, and if properly laid and of good materials gives a roofing which by long experience has been shown to be economical and efficient.

When Most Economical, Tile or Brick Protection.

Where the roof is to be subjected to wear, and where the character of the construction warrants the expense, flat tiles or brick should be used as a protective coating to the roofing instead of gravel or slag.

Coal-Tar in Preference to Asphalt.

For the flat roof built under average conditions, coal-tar pitch is recommended in preference to asphalt products. It is more easily handled, requiring less skill, and, while more material is necessary, it is still cheaper, and in our opinion more certain results can usually be expected from its use when laid by the average contractor. The large amount of material, while heavy has insulating value. Good results, however, can be expected from built-up roofs using good asphalt compounds, where laid by skilled workmen.

Built-up Roofs on Steeper Slopes Difficult.

When the slope of the roof is over three inches to the foot, the application of a built-up roof becomes more difficult for both coal-tar and asphalt, it being harder to get even mopping, and there is more chance of accident for the men. The desirable straight-run coal tar pitch cannot be used, it being necessary to add some stiffening material, which is supposed to somewhat affect the life of the pitch. This must not be done except under supervision skilled in such work, and especial care must also be taken in the selection and application of the stone or slag coating.

Ready Roofing.

Built-up roofs with a ready roofing for the coating sheet are proposed by various manufacturers. They should have their best value for steep slopes.

Advantages of Coal-Tar Pitch.

The advantage of a coal-tar pitch built-up roofing are such that it is recommended that where a permanent roof is desired, and where the character of the structure allows, the building be so designed as to allow its use. A flat roof makes an economical structure and has small fire hazard. A pitch of from one-half to one inch to the foot is better than anything steeper.

Life of Roof.

With proper materials and application, a life of from fifteen to twenty years can be expected with a flat roof.

Flashings—Avoiding Cheapness.

No contracts should be made for a built-up roof without a complete and positive specification including flashings, and the contract prices should not be less than those of the materials specified, plus a reasonable amount to cover the cost of laying and profit.

Inspection.

Thorough inspection of workmanship and material is recommended.

READY ROOFING.

Better for Steeper Slopes.

The ready roofing has better value for the steeper roofs than for those of small pitch. It averages much cheaper than the built-up types. Most kinds, to get a fair life, require occasional recoating. For flat slopes they are hard to lay absolutely tight, and they are not economical for a permanent structure, but on slopes of from three inches to the foot up their use is more justifiable.

Recommended for Temporary and Inexpensive Buildings.

Ready or prepared roofings are recommended for use on small, temporary and other buildings, where the cost, considering maintenance of more expensive roofings, is not justified. They are also of value for steep slopes, where a built-up coal-tar cannot be used, and for locations where the skilled labor necessary for a built-up roof is not available. The steeper the slope the greater their relative value and the wider their economical field.

Heavier Varieties, Longer Life.

The heavier varieties are, in general, the more desirable because of their chance for longer life and their greater fire-resisting value. In making selections the reliability of the manufacturer, service tests and the cost should be governing factors.

Ready Roofing Shingles.

On the steeper slopes the use of ready roofing shingles, properly reinforced so as to prevent curling up at the corners and fraying on the exposed edges and laid shingle fashion, is growing. They are supposed to give better results than the rolled goods, but cost more. They would seem at least to be worthy of investigation.

SLATE AND TILE.

Slate makes a good roof if of good quality and properly watched. It breaks easily and cannot be walked on without danger to the slate.

Tile of good quality gives good results. It is not so tight as slate, but does not break easily. It has architectural value, and its use is growing with improvement in the product and in the variety of colors.

Six Inches per Foot Slope or Over.

Slate and tile of suitable quality, properly protected and fastened, can be recommended on roofs with a pitch of six inches to the foot or over, where expense is not the governing feature, and where they aid in producing the desired architectural effect, except that where there is much chance of driving snow, eight inches to the foot should be the flattest slope allowed.

ASBESTOS SHINGLES.

Shingles of asbestos and Portland cement are of value. They have some elasticity and can be laid tighter than slate. They come in a variety of shapes and colors and can be laid in various patterns.

WOOD SHINGLES.

Wood shingles are not desirable for a railroad structure on account of fire hazard.

CEMENT TILE.

Small cement tile are not considered of much value, being brittle. Large cement tile, reinforced, laid without sheathing directly on the purlins, are in use on shops and freight houses and seem to have considerable merit. Glass can be introduced into them, avoiding the expense of skylights. It is not deemed advisable to recommend them for plastered or heated buildings or offices, where an occasional slight leak would be disastrous.

METALLIC ROOFINGS.

Metallic roofings with steel as a base are not recommended for general use on permanent buildings.

Continual Maintenance.

They require continual maintenance. Galvanizing of steel seems to be well worth the expense. Tests of lead-covered steel sheets indicate good results.

Unheated Buildings.

Large sheets of corrugated galvanized steel can sometimes be used economically where the building is not to be heated.

Metallic Shingles.

Small metallic shingles of either copper, tin, galvanized steel plate or specially pure iron are not recommended for general use. They are very light in weight, but serve a purpose in the dry climate of the Southwest.

Pure Iron Base.

In using metals every effort should be made to secure those of good quality. The pure irons have value. Their virtues have, perhaps, been overstated, but they are not expensive, and experience seems to indicate considerable economy by their use as a substitute for wrought-iron and steel.

GENERAL.

Thorough Workmanship.

In the laying of all roofings thoroughness in preparation of flashings and work around openings is of vital importance.

To get a satisfactory roof there must be a stable structure. Careful attention must be given to the design of gutters, and with some types, particularly, there must be systematic inspection and regular repairs. In buying a roof its fire-resisting qualities, to a considerable extent depending on the quantity of material as well as its quality, are of great importance. A building covered with a heavy coal-tar pitch and gravel roofing is a better fire risk than one covered with corrugated steel sheets or with a light ready roofing.

Guarantees Unreliable.

The practice of depending merely upon guarantees in selecting roofings cannot be trusted to secure proper results.

Saving in First Cost.

The annoyance and indirect expense occasioned by leaky and short-lived roofs are rarely compensated for by any possible saving in first cost.

[7]PRINCIPLES COVERING DESIGN OF INBOUND AND OUTBOUND FREIGHT HOUSES.

Economical Handling.

The economical handling of less-than-carload freight at terminals is a problem that is giving a great deal of concern. The cost of handling a ton of freight a mile by trains is known (approximately), but it is almost impossible to figure the cost per ton mile for trucking and handling of unclassified freight at the freight house. Freight house design should receive serious consideration.

Frame Building.

In outlying districts, where fire hazard is not great, business not large and the building laws will permit, frame freight houses having wood floors on joists, studding covered with wood sheathing or metal siding, and wood rafters and sheathing covered with appropriate roofing, are fairly satisfactory and cost less than any other type. Floor for this type should ordinarily be designed to carry 250 lbs. per square foot.

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[7] Adopted, Vol. 15, 1914, pp. 710, 1099; Vol. 16, 1915, pp. 751, 1150.

Floor Ventilation.

With such construction there should be ventilation beneath the floor. Access to the space under the house should be prevented to avoid the accumulation of rubbish and increase fire hazard.

Filled Floor.

Even where a frame house is to be used it is better practice to use a fill between masonry foundation walls, eliminating some fire hazard and decreasing maintenance charges.

Fireproof Building.

Where the laws prohibit frame structures, the value of freight stored is considerable, and it is necessary to build freight houses of so-called fireproof material. Floors should be placed on a fill between foundation walls, and the exterior walls should be of masonry or steel frame covered with metal siding. Roof trusses, framing, etc., can be of wood covered with appropriate roofing, but to provide better protection fireproof construction should be used.

Fire Walls—Areas Between.

Fire walls of brick or other non-combustible material should be located so as to conform to the requirements of the underwriters. The strictest practice limits the area between fire walls to 5000 square feet. This especially applies to houses with no outside platform. In wide houses this locates the walls rather close together for economical operation. Fire walls should in no case be more than 200 feet apart.

Doors in Fire Walls.

Doors in fire walls should be as limited in number as possible No one-door opening should exceed in area 80 square feet, and all openings should be equipped with automatic fire doors.

Cover Each Side of Fire Wall in Non-Fireproof Buildings.

Where non-fireproof construction is used, the construction at the ends of the fire walls should be fireproof for a distance of at least five feet on either side of the fire wall. This is especially desired where there are overhanging roofs.

Width.

Where but a single house is needed, a width of from 30 to 40 feet is good practice.

Separate Inbound and Outbound Houses.

When the amount of freight handled is sufficient to justify it, separate houses for inbound and outbound freight are desirable. When these are provided the outbound house should be narrow, not more than 30 feet wide, and the inbound 40 to 60 feet wide, it being considered expensive operation where a house is in excess of 60 feet in width.

Platforms.

A platform 8 to 10 feet wide along the track side of the house avoids the necessity of considering the location of doors in spotting cars on the track next to the house, and also eliminates the necessity of keeping an aisleway inside the house on the track side. It should be at least 8 feet wide to give sufficient room for hand trucks to pass, and where electric trucks are used the platform should be at least 12 feet wide.

Distance to Center Line of Track.

The distance from the center of the nearest track to the face of the platform or freight house should be not less than 5 feet 9 inches, where tracks are on tangents. The alternative of spacing tracks at least 7 feet from platforms is usually expensive at important terminals.

Distance Platform to Top of Rail.

The top of rail should be not more than 4 feet below the floor or platform level at the track edge, where refrigerator cars are not to be handled in any quantity. With occasional refrigerator cars the doors can be opened before the cars are set.

For Refrigerator Cars.

Where refrigerator cars are to be handled regularly, the height should not be more than 3 feet 8 inches, this conforming to the recommendation of the M. C. B. Association. (See Proceedings for 1911, Vol. 45, p. 728.) Many roads are building cars that are lower than the maximum figures given above, and each road, in deciding the height of platform above the top of rail, should take into consideration the sizes of cars that predominate on its line.

Roof Over Platform.

The platform should be protected by an overhanging roof, not greater than the width of the platform and at least 10 feet above the platform level.

Roof Over Cars.

Where State laws permit, protection over the cars is often used. This should be at least 17 feet above the top of rail, and should preferably extend to within 18 inches of the middle of the car. This will allow walking on the top of cars.

Eaves Above Driveway.

On account of lightweight merchandise being piled high on trucks, it is desirable to have the edge of the eaves at least 14 feet above the level of the driveway, where local conditions will permit.

Height of Doors.

As all freight trucked into the house and cars must pass through the car door, the height of the freight-house door need be little greater than the car door. All doors should be at least 8 feet high. On the team side a greater height might at times be convenient.

Roof Over Teams.

There should also be an overhanging roof or other protection on the team side to protect goods while being unloaded, the overhang to be at least 4 feet and preferably more, 12 feet at least being needed to give protection from a driving rain.

Freight House Without Outside Platforms.

Freight houses without outside platforms may be desirable in some localities, especially in northern climates, where there is considerable snow and sleet, as these houses can be entirely closed, except for that part of the house where the freight is being received or loaded. At some points, where ample track room is not available, the elimination of the outside platform possibly gives better results.

With this type it is necessary to leave more trucking space inside the house, longitudinally the full length of the building. With the house congested with freight it is difficult to keep the aisleways from being crowded up, making it almost impossible to get through with a truck that is loaded with large packages. This causes delay and confusion.

Floor Above Street Grade.

On the street side the floor of the inbound house should be from 3 feet to 4 feet above the street grade, depending on the type of trucks in use. At the outbound house the height should not exceed 3 feet.

Slope of Floor.

To assist trucking the floor of the inbound house should be sloped toward the street approximately 1 inch in 8 feet, this being for the house proper. An outside platform on the track side should slope approximately 1 inch toward the tracks for draining.

For the outbound house the floor should slope from the street to the edge of the platform alongside of the car not more than 1 inch in 8 feet.

Doors.

Several kinds of doors are satisfactory—counterbalance lift (either folding or not), rolling shutters and parallel sliding.

It is advantageous to have as much door opening on the team side as possible. With all types of doors except the last, all of the house can be opened except for the space occupied by posts.

With the parallel sliding doors not more than half of the space can be opened up. This is not objectionable on the track side.

Continuous Doors Where No Platform.

With the outside platform continuous doors should be used, so that an opening can be obtained at any point opposite a car door.

Panel Length.

Where an outside platform is provided, a door in each panel is sufficient. Considering the average length of cars and economy in framing, 22 feet is a good panel length.

No Posts.

It is advantageous to have the floor entirely free from posts, but in houses approaching 50 feet in width the saving made by using posts becomes considerable and great enough to offset the advantages due to their omission.

Natural Light.

Natural light should preferably be provided in the side walls above the doors. Skylights in the roof are expensive to maintain and ineffective, as is also glass in canopies, or on any plane approaching the horizontal.

Artificial Light.

Artificial light is needed for operation at night and during the late afternoon in the winter, and wherever possible electricity should be used, with wires run according to the specifications of the National Board of Underwriters. One or more lines of lights should be run the full length inside the house, and one line over outside platforms.

Push Plugs for Cars.

Another circuit should be run along the face of the platform wall parallel to the track, with outlet boxes not over 44 feet on centers, with socket arrangement for push plug for use in attaching an extension cord to hang inside the car to provide light for loading on dark days and evenings during the winter season.

The type of lights will depend somewhat on the height of the ceiling. All lights should be stationary and operated in circuits from conveniently located panel-boards. The circuits should be carefully planned, so as to allow maximum economy in use of lights.

Fire Protection.

Where water pressure is available there should be provided for fighting fire standpipes and hose racks not more than 150 feet apart. By putting them on the fire and end walls they are thought to be more accessible and less liable to be blocked by freight than if located at other points, but by putting them about 44 feet from the end of each section fewer hose connections are necessary to cover the entire station. As there is no heat in the house, the valve controlling the water supply should be located below the frost line and controlled by a stem with a hand wheel above the floor. The valve should be located in a pit, so as to be readily accessible for repair or renewal. It should be drained into the pit, and this in turn be connected to the sewer. A 2½-inch standpipe of wrought-iron should be run up to approximately 8 feet above the floor, and to this should be attached a hose rack, equipped with 50 feet of 2-inch linen hose. The Underwriters now recommend 1½-inch hose wherever it is to be handled by inexperienced men, but provision should be made on the water line for a 2-inch outlet for city hose; care being taken that the threads on the outlet are the same as the city equipment.

Red Light.

In houses where electricity is available there should be over each hose rack a small red light to designate the location of the fire-fighting apparatus, this light to be kept burning at all times.

Chemical Extinguishers.

Chemical extinguishers should be provided in addition to the hose and standpipes. As they are put out of service by freezing, some provision should be made for replacing them or keeping them warm. Tanks containing a solution of calcium chloride are used successfully.

Watchman's Clock.

Where a watchman is needed, watchman's clock system, with a registering clock in the freight office and stations located at various places throughout the freight houses, should be installed.

Scales.

In outbound houses sufficient scales should be provided so that all the freight can be weighed. From 50 to 80 feet apart is good practice. In inbound houses, where little of the freight is weighed, scales should be placed at least one in each section. The scales should have a minimum capacity of four tons. A successful dial scale expedites the handling of freight.

Checkers' Stalls.

Stalls for checkers should be located at least one in each section. These should be approximately 4 feet 6 inches by 4 feet 6 inches, with a shelf along the back and drawers beneath. Sometimes they are left entirely open in front, and sometimes are closed up and heated, depending on local conditions. Some roads make their checkers' stalls portable, so as to allow them to be moved in case of a special congestion of freight at certain points, but this is not ordinarily considered necessary.

O., S. and D. Room.

In inbound houses a room should be provided to house "over, short and damaged freight," this to be enclosed so that it can be kept locked.

Repair Room.

In large layouts, particularly where there is considerable transfer business, a room should be provided for repairing broken packages, such as crates, boxes, barrels, etc.

Offices.

In large houses a separate office should be provided for the foreman. If this can be an elevated structure it will save floor space.

In large houses the general office for the clerks and the private office for the agent should be provided by a second story over the inbound house, and in the second story should also be a space for files and stationery cases, toilets and locker facilities for clerks. This all should, as far as possible, be in view from the desks of the agent or chief clerk. The cashier and his clerk should ordinarily be located on the first floor.

Where possible it is preferable to have the clerks' and agents' offices, the toilet rooms, etc., for the freight handlers and draymen, the room for "over, short and damaged freight," and the cooperage room for repairing broken packages, etc., all in one section. In the larger terminals provision may be wanted to care for perishable freight, and when it is provided it should also be located in this section.

Heating Plant and Freight Handlers' Toilets.

The basement should house the heating plant, with room for coal, and is sometimes a good place for toilets for the freight handlers and draymen and for locker and lunch rooms for the freight handlers.

Transfer Platform.

Where both outbound and inbound houses are arranged in the same layout a transfer platform is usually included. One of the best designs for covering these platforms is a butterfly shed, with the posts located in the center of the platform. Where this design is used the platform should not be less than 12 feet wide, to provide room for trucks between the posts and the cars.

Ramped Extensions for Bulky Material.

For loading and unloading agricultural implements and other large, bulky packages, platforms should be built, usually as extensions to the inbound and outbound houses, with ramps on the ends of the platforms. The extension platforms should be at least 8 feet wide, and if possible 16 feet wide, especially if covered. A stub-end track butting against a platform with a ramp is valuable.

Cranes.

Where no gantry crane is provided in the freight yard, a stiff leg or pillar crane should be provided on the end of the extension platform.

Downspouts.

It is not good practice to put downspouts inside the house, and in placing them outside they should be properly protected.

Fenders.

On the team side of all freight houses a fender should be provided to protect the walls from the wagon wheels. A good type is one made up of an 8-inch by 10-inch timber set on brackets, with a spacer or separator to keep the timber approximately 2 inches away from the wall, so that dirt will filter through and not collect on the fender.

Storage.

In large cities it is frequently advisable to build the inbound houses eight to ten stories high, using the ground floor for handling freight and the balance of the structure for storage, to be leased to shippers. Most of the material stored will not be affected by heat or cold, but provision should be made for cold and warm storage where conditions warrant.

[8]REST HOUSES.

Purpose.

Rest houses are built to furnish hotel accommodations for trainmen held at terminals away from home. The need of these houses is increasing with the construction of large terminals away from the centers of the towns. With them the men can be given clean and satisfactory accommodations, are kept out of temptation, are in better condition for their work, and are close at hand when wanted. The success of the house is dependent very largely upon the manager. With a man having the requisite ability and enthusiasm the house and its associations can be made attractive and to have a valuable influence.

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[8] Adopted, Vol. 16, 1915, pp. 766, 1151.

Railroad Y. M. C. A.

The Railroad Y. M. C. A., which operates many of the houses, is able to help find good managers and through its experience to assist in getting good results. Its methods, which put part of the management upon the men, usually works successfully. A house built for their use is not different from what will give good results if run directly by the railroad.

Site.

Too often proper attention is not given to getting a desirable site, the fact being overlooked that the extra cost of such a site may be a very small part of the total. Questions of freedom from smoke and noise, of accessibility for supplies, water supply and sewage disposal, the chance of using exhaust steam from a shop heating plant for heating, an attractive outlook and the convenience of the men using it are all-important.

Sewage.

Where a sewer is not accessible, a septic tank for treatment of sewage is desirable.

Requirements of Design.

The design of the rest house must vary with the character of the traffic in which the men to be accommodated are engaged. At some points the taking care of regular boarders, such as shopmen, switchmen and telegraph operators, and the average length of lay-over of the roadmen must be considered.

Entrance.

There should be but one public entrance. The entrance lobby should be a room large enough to serve as a center for the activities of the building, and to contain an office for the manager.

Attractiveness.

Especial effort should be made to have it attractive and give a pleasing first impression.

Register and Sales Counter.

There should be a counter where a register can be kept, and also space provided for the sale of necessary articles.

Office With View.

The office should have room for a desk, where necessary clerical work can be done. It should be located so that the attendant can have the fullest possible view of the reading and amusement rooms and of the dining room.

Private Office.

A private office for the manager is sometimes thought necessary, but in smaller houses this can be avoided.

Check Room and Safe.

There should be a check room and a safe for valuables.

Lockers.

Lockers, allowing the storage of articles to be left in the house between trips are also desirable. To them the men should have access, and they can usually be put in the basement.

Bedrooms.

No provision is ordinarily made for using the bedrooms except for sleeping purposes.

Counter Lunch for Freight Trainmen.

For the house serving mostly freight trainmen, tables are not necessary in the dining rooms, and a counter gives in many ways more satisfactory results. It is easier and cheaper to serve, and less space is required. The roadmen ordinarily prefer the counter.

Tables for Regulars and Passenger Men.

Where there is a considerable proportion of regular boarders or passenger men there should be tables in addition to the counter.

Tablecloths.

Tablecloths are very hard to keep in an attractive condition, and sometimes the tables are used without cloths. However, some of the Y.M.C.A. men think that a table set with a cloth is worth the cost, in that it has a restraining home influence.

Counter.

The counter top, as a rule, is 3 feet 1 inch above the floor, but some counters are built approximately 30 inches above the floor—the same as a table—and in counters of this height it allows the men to sit and place their feet on the floor instead of having to use a foot-rail.

Impervious Top.

The top should have an impervious surface without cracks and openings where dirt and vermin can lodge, and the whole counter should be so constructed that the top will project approximately 12 inches, so that a man can sit close to the counter without striking his knees.

Open Under Counter at Floor.

A space of at least 6 inches should be left between the floor and bottom of the counter to admit of thorough cleaning.

U-Shaped Counter.

It is usually better to have the counter U-shaped (with the waiters in the center), rather than around the sides of the room, with the attendants working between it and the wall. This allows quicker service. For the ordinary house the counter should be so located that ready access can be had for the attendant at the counter to the desk at the office. At the smaller houses, particularly, this will allow for cutting down of the force to one man at night.

Stools.

At the lunch-counter metal stools with revolving wood tops and a large flaring base that can be securely fastened to the floor are recommended. They should be spaced not less than 27 inches on centers.

Chairs.

Metal chairs, with wood seats, are recommended at tables.

Kitchen.

Planning of the kitchen is a very important matter.

Light and Ventilation.

It should be light and have good ventilation.

Fan.

In a large kitchen an exhaust fan is desirable. This will pull from the rest of the house and will keep cooking odors out of the building.

Range Hoods.

There should, in any event, be hoods over the range to carry off odors, and the chimney should have a flue for this purpose.

Plan.

The kitchen should be so planned that there will be a minimum of interference between the waiters and the cooks and dishwashers.

Separate Waiters from Kitchen Help.

The waiters can often be kept separate from the kitchen help by the tables. The food should ordinarily move directly from the storeroom and ice box to the ranges and serving and steam tables.

Shelf Room.

Ample shelf room for dishes and stores must be planned for. While for cleanliness it seems desirable to keep the kitchen as free from shelves and cupboards as possible, it is economical to have supplies and utensils accessible; but a separate storeroom makes it harder to supervise the help, giving a convenient place for loafing.

No Outside Entrance to Storeroom.

If a storeroom is provided, it should not have an outside entrance, as it is practically impossible to keep it locked, and this encourages thieving.

Ice Box.

Too often sufficient room is not allowed for the ice box. There should be no skimping in providing ample refrigeration, as without it there is a chance for considerable loss. The location of the ice box is important.

Outside Ice Door.

It should have an outside opening for the ice. Adequate drainage should be provided.

Steam Tables.

Steam tables should be provided where practicable, even in the small houses. They save fuel, are cleanly and for many articles give better results than a range.

Pastry Room.

With a separate pastry room in the larger houses the work can then be done without interference with the regular work and with more cleanliness. In a small house such an arrangement would require more help, and is not ordinarily desired.

Cool Room.

In the basement a cool room is desirable so that large quantities of vegetables can be bought at one time.

Coal Storage.

In the basement there should be provided ample room for the storage of coal for ranges and for the heating plant, where impossible to locate the plant outside of the main building. Frequently a bin large enough to take a carload is desirable. A small metal coal bin should be provided near the kitchen range.

Heat.

It is good practice to locate the house so that heat can be had from a shop power plant. With a vacuum heating system steam can be economically piped for at least half a mile under favorable conditions.

Sleeping Rooms.

Sleeping rooms should be cut off from the rest of the house so that odors from the dining room and kitchen, and noise and smoke from the lounging rooms and office are kept out. Doors at the head or foot of the stairways are ordinarily necessary. This also allows a more economical use of heat.

Small Rooms.

Small sleeping rooms are preferable to dormitories, and for economy of space rooms 8 feet by 10 feet are recommended. The size will accommodate two beds. Chairs and coat hooks should be provided.

Ventilation.

Ventilation for the sleeping rooms should be provided by transoms over the doors; as a substitute an opening of approximately two inches at the top and bottom of the doors can be used.

Roof Ventilation.

Ventilation over the ceiling of the top floor is very desirable to avoid excessive heat in the sleeping rooms in hot weather.

Partitions Above Floor and Below Ceiling.

Partitions are sometimes stopped about a foot from the floor and a foot or two from the ceiling. This puts control of ventilation and heating of the sleeping rooms in charge of the manager, but gives a house which is hard to keep clean, and the half-open rooms cannot be fumigated or swept without disturbing occupants of adjacent rooms. Noisy men in one room may disturb everybody else on the same floor. With full partitions, occupants of rooms are able to adjust heat and ventilation to suit themselves. Some houses with open partitions have a screen between the partition and the ceiling and floor to keep intruders out.

Outside Windows.

Every sleeping room should be provided with an outside window.

Table and Locker.

If regular boarders are to be provided for, the room should be furnished with a table and locker.

Double-Deck Beds.

Double-deck beds are being used, and while they are economical in space, they are not as desirable as single beds. Under average conditions beds for about 75 per cent. of the number to be provided for daily are necessary.

Recreation Rooms.

The amount of room for amusement, reading, etc., is to be determined by the character of the service for which provision is made. It is important that no skimping be done in this respect if full value is to be had from the house.

It seems to be the generally accepted opinion that open rooms connected together with wide openings are better than reading and amusement rooms separate from the lobby. The men can be kept under the eye of the manager easily, and the number who want quiet is not ordinarily great, although in a big house provision for them may be desirable. Provision for bowling alleys, pool tables and other games in addition to the reading room are desirable, bowling alleys to be located where the noise will be least objectionable.

Porch.

A big porch adds much to the comfort of the house; as a general proposition it should not be located on the street side, as some men are likely to make unbecoming remarks to passersby.

Foot Rest.

A foot rest of 3-inch gas pipe, about ten inches out from the porch rail and about two feet from the floor, supported by brackets, makes a good foot rest and saves wear on the paint.

Toilet Room Floors.

The toilet room floors should be of composition or tile.

Breakage of Fixtures.

Much damage has been done by leakage from shower baths on the upper floors and especial care should be taken to prevent this.

Separation of Fixtures.

For sanitary reasons the baths and washrooms should be separate from the other fixtures.

Omission of Urinals.

Urinals are the hardest fixtures to keep clean, and, as a rule, they should be omitted and water-closets with counterbalanced seats provided.

Slop Sinks.

At a convenient location on each sleeping floor a slop sink should be provided.

Toilet on Each Sleeping Floor.

There preferably should be toilet rooms and baths on each sleeping floor.

General Toilet.

On the first floor or in the basement there should also be toilet facilities, including wash bowls. In connection with these facilities baths are desirable for those who do not wish assignment to a sleeping room. It is preferable to have them convenient to the lockers.

Few Tubs.

Very few tubs should be used, as it is almost impossible to keep them and the floor underneath properly cleaned, but there are some men who prefer the tub to the shower.

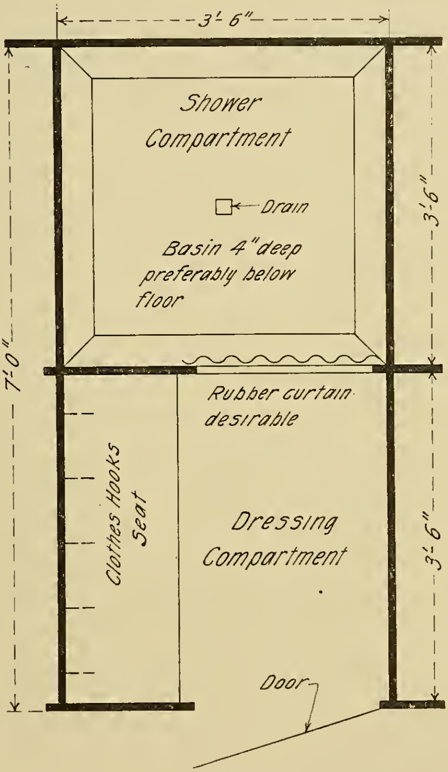

Fig. 3. Arrangement for Shower Baths in Rest Houses.

Individual Showers.

Individual showers where provided should be arranged as illustrated in Fig. 3.

Linen Closets.

Linen closets should also be provided on the sleeping room floors, and ample room for storage in connection with the office is also desirable. Dark spaces not available for sleeping rooms can be thus utilized.

Lecture Room.

A room which can be used for lectures and assemblies of various kinds is sometimes quite desirable, especially where it is possible to make some effort for entertainment of the men. Such rooms are also at times valuable for the railroad officers in handling investigations and instruction classes, the rest house being often a desirable place for such work. However, it has been found by experience at some houses that such rooms were not used often enough to warrant their cost and that, where necessary, a part of one of the amusement rooms could temporarily be shut off.

Emergency Hospital.

Consideration should be given to the provision of a small emergency hospital.

Quarters for Manager and Family.

In many localities suitable quarters for the manager and his family are necessary in the building.

Separate Toilet for Women.

Where there is a possibility of women being employed, the house should be so designed that sleeping quarters and toilet facilities can be furnished for them separated from the rest of the building.

Provision for Expansion.

In planning the house it is always well to make provision for expansion. A very large majority of the houses already built have had to be increased in size or are badly in need of it.

Lighting.

Electricity should be used for lighting even if a separate plant for providing it is necessary. It is cleaner and the danger from fire is much less when it is used.

Fire Protection and Safety Appliances.

Fire extinguishers, fire escapes, fire gongs and all the best appliances for fire prevention should be used. A fireproof building is to be strongly recommended. In frame houses the kitchen should always be built with a view to fire protection.

Sanitary Floors.

If a wooden structure is necessary, some sanitary floors can be provided, but with a brick or concrete building their use can be more extended and other improvements, such as a sanitary base, can be more easily provided.

Fireproof Cost.

A fireproof structure will cost approximately 50 per cent. more than a wooden building.

Sanitation Made Easy.

No reasonable expense should be spared in making it easier to keep the house sanitary. The houses ordinarily get shabby very easily and materials and colors should be selected which will wear well. Where plastered walls are used in the game rooms, lobbies and halls, it is desirable to have the walls, for a height of four feet; painted with dark paint.

Environs.

Provision should be made for pleasing exterior surroundings—walks, shrubs and perhaps also provision for croquet and quoits.

[9] METHOD OF HEATING FOR MEDIUM-SIZED STATIONS.

Stations with one or two waiting rooms, and an office, can be heated satisfactorily and economically by the use of stoves, especially where it is not necessary to maintain an even temperature throughout the entire day. The danger of fire from the use of stoves should be guarded against as much as possible.

Where two or more waiting rooms separated by an office are to be heated, a single central heating plant, preferably in the basement, is recommended as being the most economical and satisfactory. For such a heating plant a hot water, steam or hot air furnace may be used. The hot air furnace constitutes a greater fire risk than either the steam or hot water heater. An even temperature is more easily maintained by hot water than by steam, but a station is more quickly heated with a steam system than with a hot water system. The pipes and radiators of a hot water system must be kept above a freezing temperature.

[10] METHODS OF LIGHTING MEDIUM-SIZED STATIONS.

Electricity is the safest, most satisfactory and desirable method of lighting, and should be installed in all stations where reliable current is available at reasonable cost.

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[9] Adopted, Vol. 16, 1915, pp. 774, 1151.
[10] Adopted, Vol. 16, 1915, pp. 777, 1151.

[11] SANITARY PROVISIONS FOR MEDIUM-SIZED STATIONS.

Where water and sewers are available, water closets should be provided in the building.

Where water is available, but no sewer, then water closets in the building should be connected to septic tank.

Where neither water nor sewer is available, chemical closet or incinerator should be used in preference to a privy, which should only be used as a last resort.

In all stations different planes should be connected by curves; all heads and angles that may collect dirt and protect disease germs should be avoided; and sufficient artificial light should be provided, as dark places are the ones that collect dirt and filth.

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[11] Adopted, Vol. 16, 1915, pp. 780, 1151.

COMMITTEE VII.

WOODEN BRIDGES AND TRESTLES.

[1] DEFINITIONS.

Wooden Trestle.—A wooden structure composed of upright members supporting simple horizontal members or beams, the whole forming a support for loads applied to the horizontal members.

Frame Trestle.—A structure in which the upright members or supports are framed timbers.

Pile Trestle.—A structure in which the upright members or supports are piles.

Bent.—The group of members forming a single vertical support of a trestle, designated as pile bent where the principal members are piles, and as framed bent where of framed timbers.

Post.—One of the vertical or battered members of the bent of a framed trestle.

Pile.—(See definition under subject of Piles and Pile Driving.)

Batter.—A deviation from the vertical in upright members of a bent.

Cap.—A horizontal member upon the top of piles or posts, connecting them in the form of a bent.

Sill.—A lower horizontal member of a framed bent.

Mud-Sill or Sub-Sill.—A timber bedded in the ground to support a framed bent.

Intermediate Sill.—A horizontal member in the plane of the bent between the cap and sill to which the posts are framed.

Sway Brace.—A member bolted or spiked to the bent and extending diagonally across its face.

Longitudinal Strut or Girt.—A stiffening member running horizontally, or nearly so, from bent to bent.

Longitudinal X Brace.—A member extending diagonally from bent to bent in a vertical or battered plane.

Sash Brace.—A horizontal member secured to the posts or piles of a bent.

Stringer.—A longitudinal member extending from bent to bent and supporting the track.

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[1] Adopted, Vol. 6, 1905, pp. 35, 36, 42, 55-67; Vol. 7, 1906, pp. 683, 684; Vol. 11, Part 1, 1910, pp. 178, 228; Vol. 16, 1915, pp. 894, 1179.

Jack Stringer.—A stringer placed outside of the line of main stringers.

Bridge Tie.—A transverse timber resting on the stringers and supporting the rails.

Inner Guard Rail.—A longitudinal member, usually a metal rail, secured on top of the ties inside of the track rail, to guide derailed car wheels.

Guard Timber.—A longitudinal timber placed outside of the track rail, to maintain the spacing of the ties.

Packing Block.—A small member, usually wood, used to secure the parts of a composite member in their proper relative positions.

Packing Spool or Separator.—A small casting used in connection with packing bolts to secure the several parts of a composite member in their proper relative positions.

Drift Bolt.—A piece of round or square iron of specified length, with or without head or point, driven as a spike.

Dowel.—An iron or wooden pin, extending into, but not through, two members of the structure to connect them.

Shim.—A small piece of wood or metal placed between two members of a structure to bring them to a desired elevation.

Fish-Plate.—A short piece lapping a joint, secured to the side of two members, to connect them end to end.

Bulkhead.—A wall of timber placed against the side of an end bent to retain the embankment.

[2] PILES AND PILE DRIVING.

Pile.—A member usually driven or jetted into the ground and deriving its support from the underlying strata, and by the friction of the ground on its surface.

The usual functions of a pile are: (*a*) To carry a superimposed load; (*b*) To compact the surrounding ground; (*c*) To form a wall to exclude water and soft material, or to resist the lateral pressure of adjacent ground.

Head of Pile.—The upper end of a pile.

Foot of Pile.—The lower end of a pile.

Butt of Pile.—The larger end of a pile.

Tip of Pile.—The smaller end of a pile.

Bearing Pile.—One used to carry a superimposed load.

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[2] Adopted, Vol. 10, 1909, p. 565; Vol. 16, 1915, pp. 894, 1179.

Screw Pile.—One having a broad-bladed screw attached to its foot to provide a larger bearing area.

Disc Pile.—One having a disc attached to its foot to provide a larger bearing area.

Batter Pile.—One driven at an inclination to resist forces which are not vertical.

Sheet Piles.—Piles driven in close contact in order to provide a tight wall, to prevent leakage of water and soft materials; or driven to resist the lateral pressure of adjacent ground.

Pile Driver.—A machine for driving piles.

Hammer.—A weight used to deliver blows to a pile to secure its penetration.

Drop Hammer.—One which is raised by means of a rope and then allowed to drop.

Steam Hammer.—One which is automatically operated by the action of a steam cylinder and piston supported in a frame which rests on the pile.

Leads.—The upright parallel members of a pile driver which support the sheaves used to hoist the hammer and piles, and which guide the hammer in its movement.

Cap.—A block used to protect the head of a pile and to hold it in the leads during driving.

Ring.—A metal hoop used to bind the head of a pile during driving.

Shoe.—A metal protection for the point or foot of a pile.

Follower.—A member interposed between the hammer and pile to transmit blows to the latter when below the foot of the leads.

[3] STRUCTURAL TIMBER.

Timber.—A single stick of wood of regular cross-section.

Cross-Section.—A section of a stick at right angles to the axis.

True.—Of uniform cross-section. Defects are caused by wavy or jagged sawing or consist of trapezoidal instead of rectangular cross-sections.

Axis.—The line connecting the centers of successive cross-sections of a stick.

Straight.—Having a straight line of an axis.

Out of Wind.—Having the longitudinal surfaces plane.

Full Length.—Long enough to "square" up to the length specified in the order.

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[3] Adopted, Vol. 11, Part 1, 1910, pp. 176, 178, 228.

Corner.—The line of intersection of the planes of two adjacent longitudinal surfaces.

Girth.—The perimeter of a cross-section.

Side.—Either of the two wider longitudinal surfaces of a stick.

Edge.—Either of the two narrower longitudinal surfaces of a stick.

Face.—The surface of a stick which is exposed to view in the finished structure.

Sapwood.—A cylinder of wood next to the bark and of lighter color than the wood within. It may be of uneven thickness.

Heartwood.—The older and central part of a log, usually darker in color than sapwood. It appears in strong contrast to the sapwood in some species, while in others it is but slightly different in color.

Springwood.—The inner part of the annual ring formed in the earlier part of the season, not necessarily in the spring, and often containing vessels or pores.

Summerwood.—The outer part of the annual ring formed later in the season, not necessarily in the summer, being usually dense in structure and without conspicuous pores.

Decay.—Complete or partial disintegration of the cell walls, due to the growth of fungi.

Sound.—Free from decay.

Solid.—Without cavities; free from loose heart, wind shakes, bad checks, splits or breaks, loose slivers, and worm or insect holes.

Wane.—A deficient corner due to curvature or to taper of the log.

Square Cornered.—Free from wane.

Knot.—The hard mass of wood formed in a trunk at a branch, with the grain distinct and separate from the grain of the trunk.

Cross-Grain.—The gnarly mass of wood surrounding a knot, or grain injuriously out of parallel with the axis.

Wind Shake.—A crack or fissure, or a series of them, caused during growth.

[4] STANDARD DEFECTS OF STRUCTURAL TIMBER.

The standard defects included in the following list are mostly such as may be termed natural defects, as distinguished from defects of manufacture. The latter have usually been omitted, because the defects of manufacture are of minor significance in the grading of structural timber:

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[4] Adopted, Vol. 8, 1907, pp. 401-408, 450-452; Vol. 9, 1908, pp. 316, 375, 376; Vol. 11, Part 1, 1910, pp. 178, 228.

Sound Knot.—One which is solid across its face and is as hard as the wood surrounding it. It may be either red or black, and is so fixed by growth or position that it will remain in its place in the piece.

Loose Knot.—One not firmly held in place by growth or position. (See Fig. 1.)

Pith Knot.—Sound knot with a pith hole not more than ¼ inch in diameter* in the center. (See Fig. 2.)

Encased Knot.—One which is surrounded wholly or in part by bark or pitch. Where the encasement is less than ⅛ inch in width on each side, nor exceeding one-half the circumference of the knot, it shall be considered a sound knot. (See Fig. 3.)

Rotten Knot.—One not as hard as the wood surrounding it. (See Fig. 4.)

Pin Knot.—Sound knot ½ inch or less in diameter. (See Fig. 5.)

Standard Knot.—Sound knot not over 1½ inches or less in diameter. (See Fig. 6.)

Large Knot.—Sound knot, more than 1½ inches in diameter. (See Fig. 7.)

Round Knot.—One which is oval or circular in form.

Spike Knot.—One sawn in a lengthwise direction. The mean or average diameter shall be taken as the size of these knots. (See Fig. 8.)

Pitch Pockets.—Pitch pockets are openings between the grain of the wood, containing more or less pitch or bark. These shall be classified as small, standard and large pitch pockets.

Small Pitch Pocket (a).—One not over ⅛ inch wide. (See Fig. 9.)

Standard Pitch Pocket (b).—One not over ⅜ inch wide nor over 3 inches in length.

Large Pitch Pocket (c).—One over ⅜ inch wide, or over 3 inches in length.

Pitch Streak.—A well-defined accumulation of pitch at one point in the piece. When not sufficient to develop a well-defined streak, or where the fiber between grains, that is, the coarse grained fiber, usually termed "spring wood," is not saturated with pitch, it shall not be considered a defect. (See Fig. 10.)

Shakes.—Splits or checks in timbers which usually cause a separation of the wood between annual rings.

Ring Shake.—An opening between annual rings.

Through Shake.—A shake which extends between two faces of a timber.

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* Measurements which refer to the diameter of knots or holes shall be considered as the mean or average diameter in all cases.

Rot, Dote and Red Heart.—Any form of decay which may be evident, either as a dark red discoloration not found in the sound wood, or by the presence of white or rotten red spots, shall be considered as a defect.

Wane.—(See definition under the subject of Structural Timber.)

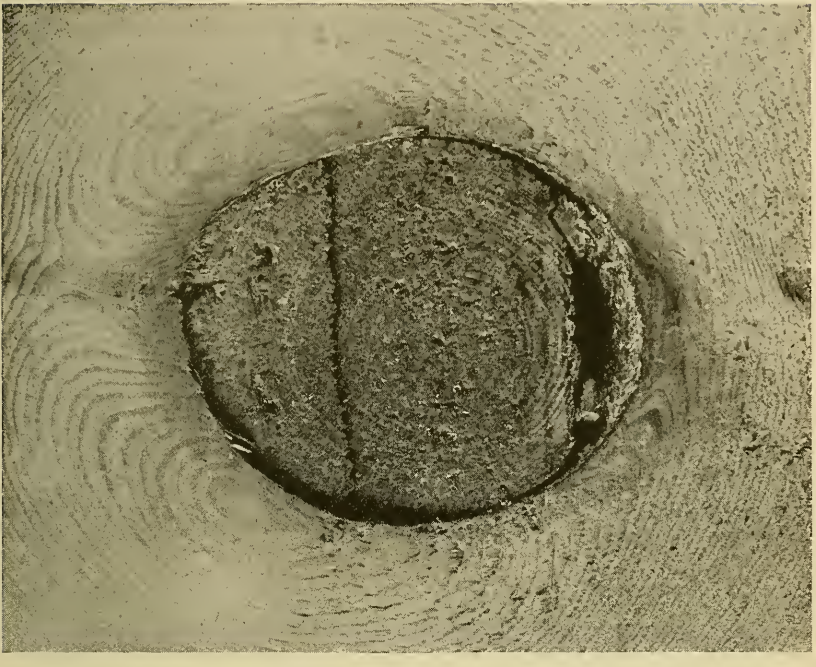

FIG. 1. LOOSE KNOT.

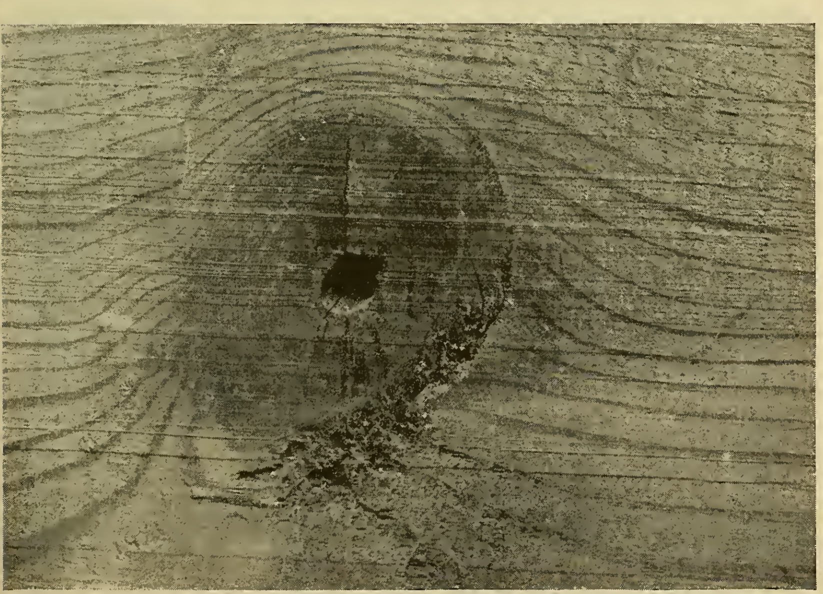

FIG. 2. PITH KNOT.

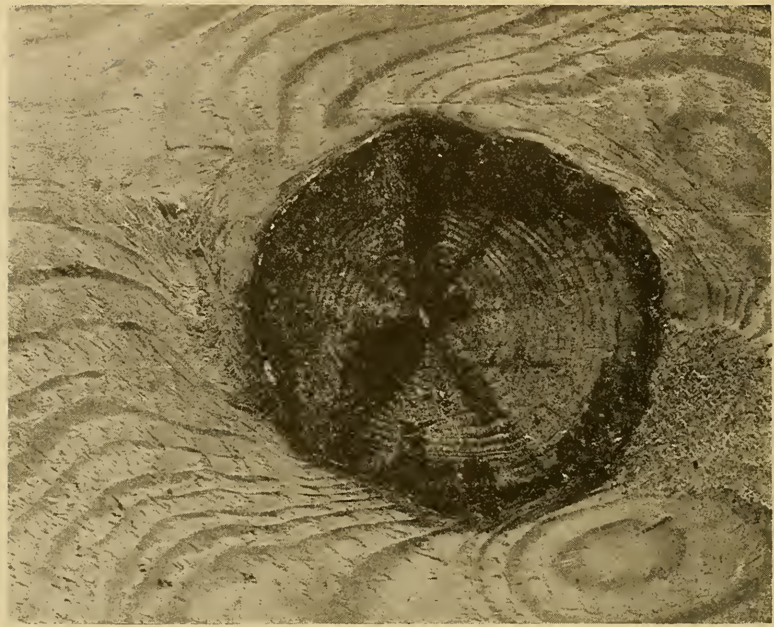

FIG. 3. ENCASED KNOT.

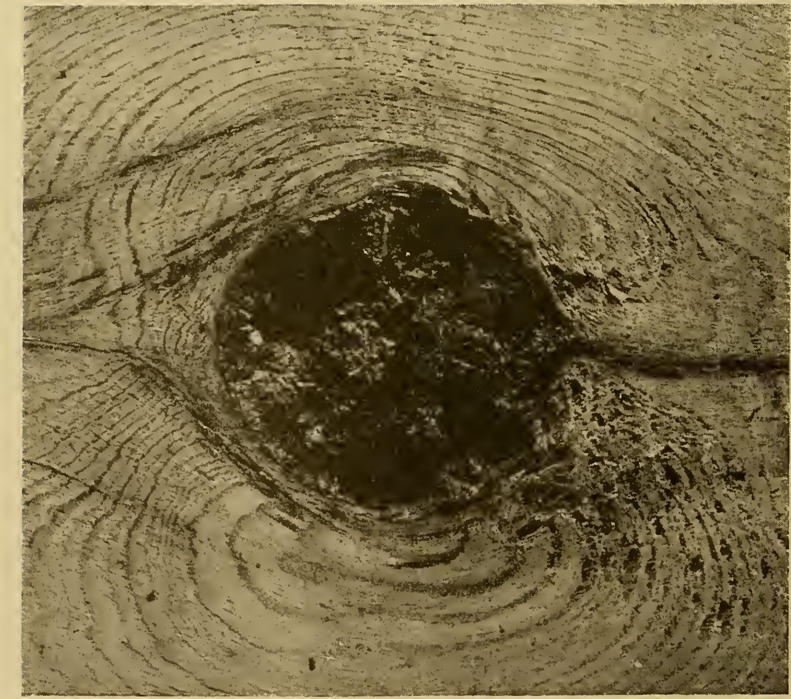

FIG. 4. ROTTEN KNOT.

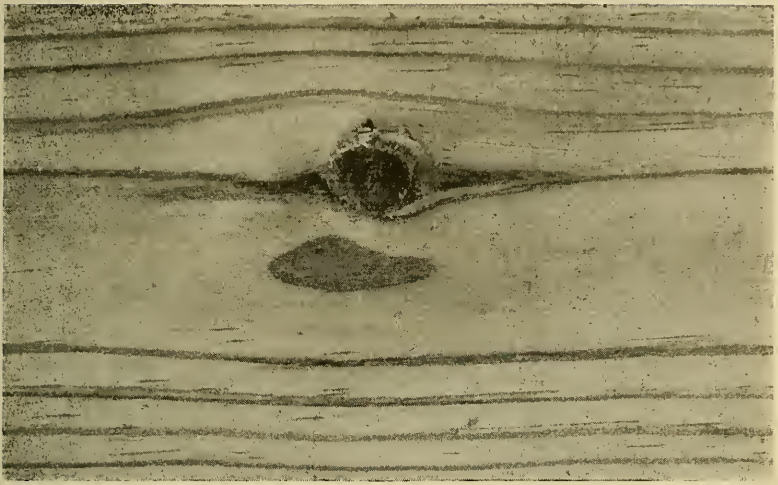

FIG. 5. PIN KNOT.

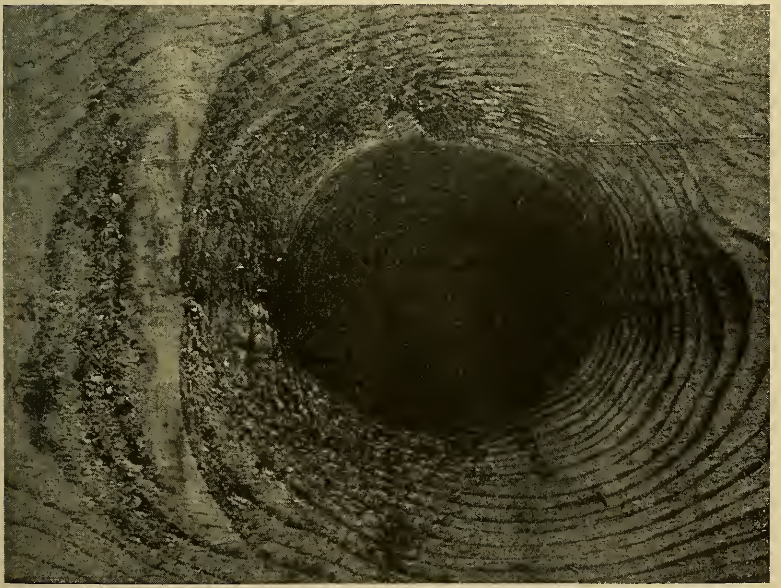

FIG. 6. STANDARD KNOT.

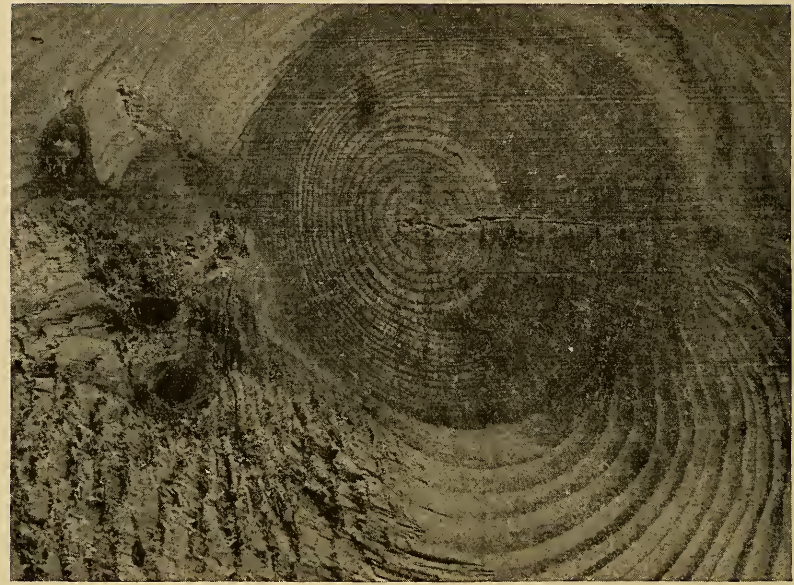

Fig. 7. Large Knot.

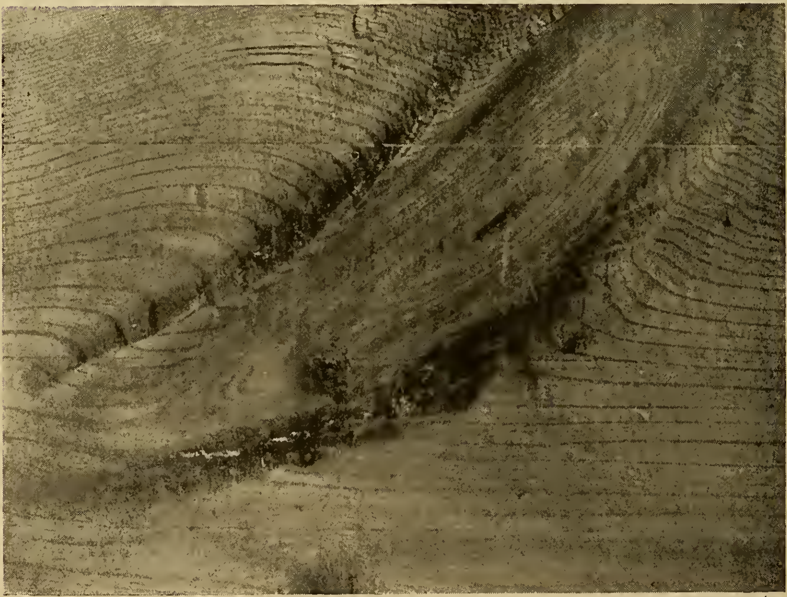

Fig. 8. Spike Knot.

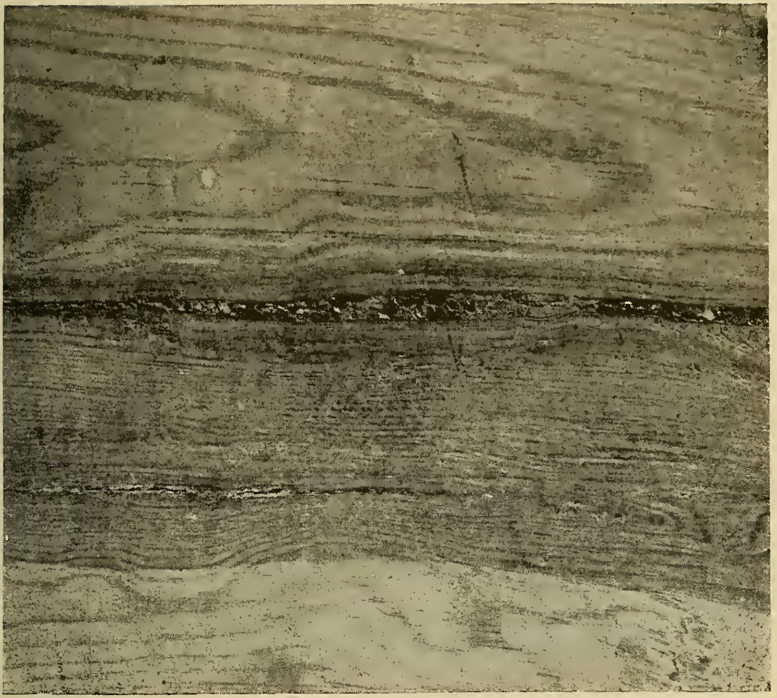

FIG. 9. SMALL PITCH POCKET.

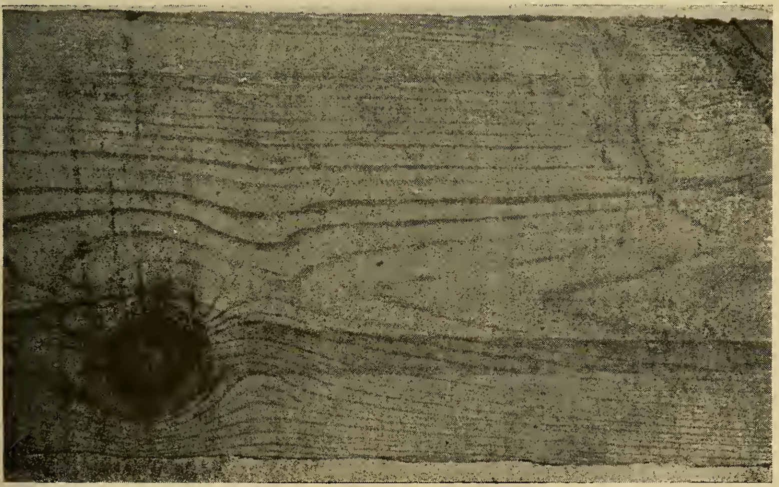

FIG. 10. PITCH STREAK.

[5] STANDARD NAMES FOR STRUCTURAL TIMBERS.

Southern Yellow Pine.—Under this heading three classes of timber are used, (a) longleaf pine, (b) shortleaf pine, (c) loblolly pine.

Douglas Fir.—The term "Douglas Fir" covers the timber known as yellow fir, red fir, Western fir, Washington fir, Oregon or Puget Sound fir or pine, Northwest and West Coast fir.

Norway Pine covers what is known also as "Red Pine."

Hemlock covers Southern or Eastern hemlock; that is, hemlock from all States east of and including Minnesota.

Western Hemlock covers hemlock from the Pacific Coast.

Spruce covers Eastern spruce; that is, the spruce timber coming from points east of Minnesota.

Western Spruce covers spruce timber from the Pacific Coast.

White Pine covers the timber which has hitherto been known as white pine, from Maine, Michigan, Wisconsin and Minnesota.

Idaho White Pine covers the variety of white pine from Western Montana, Northern Idaho, and Eastern Washington.

Western Pine covers the timber sold as white pine coming from Arizona, California, New Mexico, Colorado, Oregon and Washington. This is the timber sometimes known as "Western Yellow Pine," or "Ponderosa Pine," or "California White Pine," or "Western White Pine."

Western Larch covers the species of Larch or Tamarack from the Rocky Mountain and Pacific Coast regions.

Tamarack covers the timber known as "Tamarack," or "Eastern Tamarack," from States east of and including Minnesota.

Redwood includes the California wood usually known by that name.

Oak.—Under this heading three classes of timber are used: (a) White Oak, to include White Oak, Burr Oak and Post Oak; (b) Red Oak, to include Red Oak, Scarlet Oak, Black Oak and all bastard oaks; (c) Chestnut Oak to include only Chestnut Oak.

[6] INSPECTION OF BRIDGE AND TRESTLE TIMBERS.

It is preferable to make the inspection of bridge and trestle timber at the mills.

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[5] Adopted, 1909, Vol. 10, p. 609.
[6] Adopted, 1909, Vol. 10, pp. 537, 541.

[7] STANDARD SPECIFICATIONS FOR SOUTHERN YELLOW PINE BRIDGE AND TRESTLE TIMBERS.

(TO BE APPLIED TO SINGLE STICKS AND NOT TO COMPOSITE MEMBERS.)

General Requirements.

1. Except as noted, all timber shall be sound, sawed to standard size, full length, square cornered and straight; close grained and free from defects such as injurious ring shakes and cross grain, unsound or loose knots, knots in groups, decay, or other defects that will materially impair its strength.

Standard Size.

2. "Rough timbers sawed to standard size" means that they shall not be over ¼ inch scant from the actual size specified. For instance, a 12 by 12-inch timber shall measure not less than 11¾ by 11¾ inches.

Standard Dressing.

3. "Standard dressing" means that not more than ¼ inch shall be allowed for dressing each surface. For instance, a 12 by 12-inch timber, after being dressed on four sides, shall measure not less than 11½ by 11½ inches.

STANDARD HEART GRADE, LONGLEAF YELLOW PINE.

Stringers.

4. Stringers shall show not less than 85 per cent. heart on the girth anywhere in the length of the piece; provided, however, that if the maximum amount of sap is shown on either narrow face of the stringer, the average depth of sap shall not exceed one-half inch. Knots greater than 1½ inch in diameter will not be permitted at any section within 4 inches of the edge of the piece, but knots shall in no case exceed 4 inches in their largest diameter.

Caps and Sills.

5. Caps and sills shall show not less than 85 per cent. heart on each of the four sides, measured across the sides anywhere in the length of the piece, and shall be free from knots over 2½ inches in diameter.

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[7] Adopted, Vol. 10, Part 1, 1909, pp. 537, 539-541, 598-603; Vol. 11, 1910, Part 1, pp. 176, 180, 181, 228-230.

Posts.

6. Posts shall show not less than 75 per cent. heart on each of the four sides, measured across the sides anywhere in the length of the piece, and shall be free from knots over 2½ inches in diameter.

Longitudinal Struts and Girts.

7. Longitudinal Struts and Girts shall be square cornered and sound. One side shall show all heart; the other side shall show not less than 85 per cent. heart, measured across the side anywhere in the length of the piece, and shall be free from any large knots or other defects that will materially injure their strength.

Longitudinal X Braces, Sash and Sway Braces.

8. Longitudinal X Braces, Sash Braces and Sway Braces shall be square cornered and sound; shall show not less than 80 per cent. heart on each of the two sides, and shall be free from any large knots or other defects that will materially injure their strength.

Ties and Guard Rails.

9. Ties and Guard Rails shall show one side all heart; the other side and two edges shall show not less than 75 per cent. heart, measured across the surface anywhere in the length of the piece; shall be free from any large knots or other defects that will materially injure their strength; and where surfaced the remaining rough face shall show all heart.

STANDARD GRADE, LONGLEAF AND SHORTLEAF YELLOW PINE.

Stringers.

10. Stringers shall be square cornered, with the exception of 1 inch wane on one corner or ½ inch wane on two corners. Knots shall not exceed in their largest diameter one-fourth of the width of the surface of the stick in which they occur, and shall in no case exceed 4 inches. Ring shakes shall not extend over one-eighth of the length of the piece.

Caps and Sills.

11. Caps and Sills shall be square cornered, with the exception of 1 inch wane on one corner, or ½ inch wane on two corners. Knots shall not exceed in their longest diameter ¼ of the width of the surface of the stick in which they occur, and in no case shall exceed 4 inches. Ring shakes shall not extend over one-eighth of the length of the piece.

Posts.

12. Posts shall be square cornered, with the exception of 1 inch wane on one corner, or ½ inch wane on two corners. Knots shall not exceed, in their longest diameter, one-fourth of the width of the surface of the stick in which they occur, and shall in no case exceed 4 inches. Ring shakes shall not extend over one-eighth of the length of the piece.

EXPLANATORY NOTE FOR STANDARD HEART GRADE.

These specifications state the maximum limit of sapwood which will be accepted. In practice, with good inspection, the effect of these specifications should be to secure timber the bulk of which is practically all heart. In permanent bridge timber, not protected from decay, sapwood is not only useless in itself, but by furnishing a lodgment for the spores of fungi, it is the cause of starting and promoting the continuance of rot in the heart. Sapwood, especially after decay has set in, is also extremely susceptible to fire, while with precautions ordinarily exercised heartwood is practically immune from this source of danger.

On the other hand, for ordinary commercial purposes sapwood is as valuable as heart. Therefore, if the mill owners understand what is wanted, good heart timber can be obtained for a small advance in price over what is usually furnished, much of which contains in bulk 50 per cent. or more of sapwood.

To obtain proper results inspection should be made at the mills, where unsatisfactory timber can be rejected without hardship to the mill owner. Extensive buyers of timber should have inspectors stationed at the mills. To cover the needs of smaller buyers and municipalities, it seems that some of the established Inspection Companies might maintain an organization of timber inspectors at the mills, which would prove profitable to themselves, satisfactory to the mill owners and of incalculable benefit to those who use the timber.

[8]STANDARD SPECIFICATIONS FOR DOUGLAS FIR AND WESTERN HEMLOCK BRIDGE AND TRESTLE TIMBERS.

(TO BE APPLIED TO SINGLE STICKS AND NOT TO COMPOSITE MEMBERS.)

STANDARD HEART GRADE.

Standard Heart Grade.

1. Standard Heart Grade shall include yellow and red Douglas fir and Western hemlock. White Douglas fir will not be accepted.

General Requirements.

2. All timber shall be live, sound, straight and close grained, cut square cornered, full length, not more than ¼ inch scant in any dimension for rough timber or ½ inch for dressed timber; free from large, loose or unsound knots, knots in groups, or other defects that will materially impair its strength for the purpose for which it is intended, and subject to inspection before loading.

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[8] Adopted, Vol. 11, Part 1, 1910, pp. 182, 183, 230-234.

Stringers.

3. Stringers shall show not less than 90 per cent. heart on each side and edge, measured across the surface anywhere in the length of the piece. Stringers shall be out of wind and free from shakes, splits, or pitch pockets over ⅜ inch wide or 5 inches long. Knots greater than 2 inches in diameter will not be permitted within one-fourth of the depth of the stringer from any corner nor upon the edge of any piece. Knots shall in no case exceed 3 inches in diameter.

Caps, Sills and Posts.

4. Caps, Sills and Posts shall show not less than 85 per cent. heart on each of the four sides, measured across the surface anywhere in the length of the piece; which shall be out of wind and free from shakes, splits, or pitch pockets over ½ inch wide or 5 inches long. Knots shall not exceed one-fourth of the width of the surface of the piece in which they occur and shall in no case exceed 3 inches in diameter.

Longitudinal Struts or Girts, X Braces, Sash and Sway Braces.

5. Longitudinal Struts or Girts, X Braces, Sash and Sway Braces shall show one side all heart. The other side and two edges shall show not less than 85 per cent. heart, measured across the surface anywhere in the length of the piece.

Ties and Guard Timbers.

6. Ties and Guard Timbers shall show one side and one edge all heart. The other side and edge shall show not less than 85 per cent. heart, measured across the surface anywhere in the length of the piece.

Howe Truss Chords.

7. Timbers for Howe Truss Chords shall show not less than 90 per cent. heart on each side and edge, measured anywhere in the length of the piece. They shall be out of wind and free from shakes, splits, or pitch pockets over ⅛ inch wide or 3 inches long. Knots shall not be over 1½ inches in diameter nor be closer together on each surface than one in any four linear feet; but if knots are 1 inch or less in diameter, one knot in any three linear feet will be allowed.

STANDARD GRADE.

8. Standard Grade shall include yellow, red and white Douglas fir and Western hemlock.

General Requirements.

9. All timbers shall be sound and cut square cornered, except that timbers 10 by 10 inches in size may have a 2-inch wane on one corner or its equivalent on two or more corners. Other sizes may have proportionate defects. Must be free from defects which will impair its utility for temporary work. Knots shall not exceed one-fourth the width of the surface of the piece in which they occur. Timber must be subject to inspection before loading.

Stringers, Caps, Sills and Posts.

10. Stringers, Caps, Sills and Posts shall be out of wind, free from shakes or splits extending over more than one-eighth of the length of the piece, or knots more than 4 inches in diameter. Knots greater than 3 inches in diameter will not be permitted on the edge of any stringer.

[9] SPECIFICATIONS FOR TIMBER PILES.

RAILROAD HEART GRADE.

1. This grade includes white, burr, and post oak; longleaf pine, Douglas fir, tamarack, Eastern white and red cedar, chestnut, Western cedar, redwood and cypress.

2. Piles shall be cut from sound trees; shall be close grained and solid, free from defects, such as injurious ring shakes, large and unsound or loose knots, decay or other defects, which may materially impair their strength or durability. In Eastern red or white cedar a small amount of heart rot at the butt, which does not materially injure the strength of the pile, will be allowed.

3. Piles must be butt cut above the ground swell and have a uniform taper from butt to tip. Short bends will not be allowed. A line drawn from the center of the butt to the center of the tip shall lie within the body of the pile.

4. Unless otherwise allowed, piles must be cut when sap is down. Piles must be peeled soon after cutting. All knots shall be trimmed close to the body of the pile.

5. The minimum diameter at the tips of round piles shall be 9 inches for lengths not exceeding 30 feet; 8 inches for lengths over 30 feet but not exceeding 50 feet, and 7 inches for lengths over 50 feet. The minimum

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[9] Adopted, Vol. 10, 1909, pp. 537, 541, 542, 603-611.

diameter at one-quarter of the length from the butt shall be 12 inches and the maximum diameter at the butt 20 inches.

6. The minimum width of any side of the tip of a square pile shall be 9 inches for lengths not exceeding 30 feet; 8 inches for lengths over 30 feet but not exceeding 50 feet, and 7 inches for lengths over 50 feet. The minimum width of any side at one-quarter of the length from the butt shall be 12 inches.

7. Square piles shall show at least 80 per cent. heart on each side at any cross-section of the stick, and all round piles shall show at least 10½ inches diameter of heart at the butt.

RAILROAD FALSEWORK GRADE.

8. This grade includes red and all other oaks not included in Railroad Heart grade, sycamore, sweet, black and tupelo gum, maple, elm, hickory, Norway pine or any sound timber that will stand driving.

9. The requirements for size of tip and butt taper and lateral curvature are the same as for Railroad Heart grade.

10. Unless otherwise specified piles need not be peeled.

11. No limits are specified as to the diameter or proportion of heart.

12. Piles which meet the requirements of Railroad Heart grade except the proportion of heart specified will be classed as Railroad Falsework grade.

[10] SPECIFICATIONS FOR METAL DETAILS USED IN WOODEN BRIDGES AND TRESTLES.

Wrought-Iron.

1. Wrought-iron shall be double-rolled, tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1 or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lbs. per square inch, an elongation of 18 per cent. in 8 inches, with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent. fibrous.

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[10] Adopted, Vol. 7, 1906, pp. 692-694, 719-724; Vol. 11, 1910.

Steel.

2. Steel shall be made by the open-hearth process and shall be of uniform quality. It shall contain not more than 0.05 per cent. sulphur. If made by the acid process it shall contain not more than 0.06 per cent. phosphorus; and if made by the basic process, not more than 0.04 per cent. phosphorus. When tested in specimens of the form of Fig. 1, or full-sized pieces of the same length, it shall have a desired ultimate tensile strength of 60,000 lbs. per square inch. If the ultimate strength varies more than 4000 lbs. from that desired, a retest shall be made on the same gage, which, to be acceptable, shall be within 5000 lbs. of the desired ultimate. It shall have a minimum percentage of elongation in 8 inches of $\frac{1,500,000}{\text{ultimate tensile strength}}$; and shall bend cold without fracture 180 degrees flat. The fracture for tensile tests shall be silky.

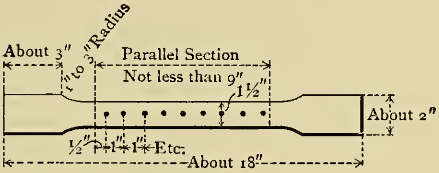

Fig. 1.

Cast-Iron.

3. Except where chilled iron is specified, castings shall be made of tough gray iron, with sulphur not over 0.10 per cent. They shall be true to pattern, out of wind and free from flaws and excessive shrinkage. If tests are demanded, they shall be made on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar 1¼ inches in diameter and 15 inches long. The transverse test shall be made on a supported length of 12 inches, with load at middle. The minimum breaking load so applied shall be 2900 lbs., with a deflection of at least 1/10 inch before rupture.

Bolts.

4. Bolts shall be of wrought-iron or steel, made with square heads, standard size, the length of thread to be 2½ times the diameter of bolt. The nuts shall be made square, standard size, with thread fitting closely the thread of bolt. Threads shall be cut according to U. S. standards.

Drift Bolts.

5. Drift bolts shall be of wrought-iron or steel, with or without square head, pointed or without point, as may be called for on plans.

Spikes.

6. Spikes shall be of wrought-iron or steel, square or round, as called for on the plans. Steel wire spikes, when used for spiking planking, shall not be used in lengths more than 6 inches; if greater lengths are required, wrought or steel spikes shall be used.

Packing Spools or Separators.

7. Packing spools or separators shall be of cast-iron, made to size and shape called for on plans. The diameter of hole shall be ⅛ inch larger than diameter of packing bolts.

Cast Washers.

8. Cast washers shall be of cast-iron. The diameter shall be not less than 3½ times the diameter of bolt for which it is used, and its thickness equal to the diameter of bolt. The diameter of hole shall be ⅛ inch larger than the diameter of the bolt.

Wrought Washers.

9. Wrought washers shall be of wrought-iron or steel, the diameter shall be not less than 3½ times the diameter of bolt for which it is used, and not less than ¼ inch thick. The hole shall be ⅛ inch larger than the diameter of the bolt.

Special Castings.

10. Special castings shall be made true to pattern, without wind, free from flaws and excessive shrinkage; size and shape to be as called for by the plans.

[11] SPECIFICATIONS FOR WORKMANSHIP FOR PILE AND FRAME TRESTLES TO BE BUILT UNDER CONTRACT.

Site.

1. The trestle to be built under these specifications is located on the line of .... Railway at .... County of ....State of ....

General Description.

2. The work to be done under these specifications covers the driving, framing and erection of a .... track wooden trestle about .... feet long and an average of ....feet high.

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[11] Adopted, Vol. 8, 1907, pp. 397-400, 442-450.

General Clauses.

3. The contractor shall furnish all necessary labor, tools, machinery, supplies, temporary staging and outfit required. He shall build the complete trestle ready for the track rails, in a workmanlike manner, in strict accordance with the plans and the true intent of these specifications, to the satisfaction and acceptance of the Engineer of the Railway Company.

4. The workmanship shall be of the best quality in each class of work. Details, fastenings and connections shall be of the best method of construction in general use on first-class work.

5. Holes shall be bored for all bolts. The depth of the hole and the diameter of the augur shall be as specified by the Engineer.

6. Framing shall be accurately fitted. No blocking or shimming will be allowed in making joints. Timbers shall be cut off with the saw; no axe to be used.

7. Joints and points of bearing, for which no fastening is shown on the plans, shall be fastened as specified by the Engineer.

8. The Engineer or his authorized agents shall have full power to cause any inferior work to be condemned, and taken down or altered, at the expense of the contractor. Any material destroyed by the contractor on account of inferior workmanship or carelessness of his men must be replaced by the contractor at his own expense.

9. Figures shown on the plans shall govern in preference to scale measurements. If any discrepancies should arise or irregularities be discovered in the plans, the contractor shall call on the Engineer for instructions. These specifications and the plans are intended to coincide, and if any question arises as to the proper interpretation of the plans or specifications, it shall be referred to the Engineeer for a ruling.

10. The contractor shall, when required by the Engineer, furnish a satisfactory watchman to guard the work.

11. On the completion of the work, all refuse material and rubbish that may have accumulated on top and under and near the trestle, by reason of its construction, shall be removed by the contractor.

Detail Specifications.

12. Piles shall be carefully selected to suit the place and ground where they are to be driven. When required by the Engineer, pile butts shall be banded with iron or steel for driving, and the tips shod with suitable iron or steel shoes. Such shoes will be furnished by the Railway Company.

13. Piles shall be driven to firm bearing, satisfactory to the Engineer; or until five blows of a hammer weighing 3000 lbs., falling 15 feet (or a hammer and fall producing the same mechanical effect), are required to cause an average penetration of ½ inch per blow, except in soft bottom, where special instructions will be given.

14. Batter piles shall be driven to the inclination shown by the plans, and shall require but slight bending before framing.

15. Butts of all piles in a bent shall be sawed off to one plane and trimmed so as not to leave any horizontal projection outside of the cap.

16. Piles injured in driving, or driven out of place, shall either be pulled out or cut off, and replaced by new piles.

Caps.

17. Caps shall be sized over the piles or posts to a uniform thickness and even bearing on piles or posts. The side with most sap shall be placed downward.

Posts.

18. Posts shall be sawed to proper length for their position (vertical or batter), and to even bearing on cap and sill.

Sills.

19. Sills shall be sized at the bearing of posts to one plane.

Sway Braces.

20. Sway bracing shall be properly framed and securely fastened to piles or posts. When necessary, filling pieces shall be used between the braces and the piles of a bent on account of the variation in size of piles, and securely fastened and faced to obtain a bearing against all piles.

Longitudinal Braces.

21. Longitudinal X braces shall be properly framed and securely fastened to piles or posts.

Girts.

22. Girts shall be properly framed and securely fastened to caps, sub-sills, posts or piles, as the plans may require.

Stringers.

23. Stringers shall be sized to a uniform height at supports. The edges with most sap shall be placed downward.

Jack Stringers.

24. Jack stringers, if required on the plans, shall be neatly framed on caps, and their tops shall be in the same plane as the track stringers.

Ties.

25. Ties shall be framed to a uniform thickness over bearings, and shall be placed with the rough side upward. They shall be spaced regularly and cut to even length and line, as called for on the plans.

Guard Rails.

26. Timber guard rails shall be framed as called for on the plans, laid to line and to a uniform top surface. They shall be firmly fastened to the ties as required.

Bulkheads.

27. Bulkheads shall be of sufficient dimensions to keep the embankment clear of the caps, stringers and ties, at the end bents of the trestle. There shall be a space of not less than 2 inches between the back of the end bent and the face of the bulkhead. The projecting ends of the bulkhead shall be sawed off to conform to the slope of the embankment, unless otherwise specified.

Time of Completion.

28. The work shall be completed in all its parts on or before .... 19....

Payments.

29. Payments will be made under the usual regulations of the Railway Company.

[12] PILE DRIVING—PRINCIPLES OF PRACTICE.

(1) A thorough exploration of the soil by borings, or preliminary test piles, is the most important prerequisite to the design and construction of pile foundations.

(2) Soil consisting wholly or chiefly of sand is most favorable to the use of the water jet.

(3) In harder soils containing gravel the use of the jet may be advantageous, if sufficient volume and pressure be provided.

(4) In clay it may be economical to bore several holes in the soil with the aid of the jet before driving the pile, thus securing the accurate location of the pile, and its lubrication while being driven.

(5) In general, the water jet should not be attached to the pile, but handled separately.

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[12] Adopted, Vol. 12, 1911, Part 1, pp. 279, 307; Vol. 16, 1915, pp. 894, 1181.

(6) Two jets will often succeed where one fails. In special cases a third jet extending a part of the depth aids materially in keeping loose the material around the pile.

(7) Where the material is of such a porous character that the water from the jets may be dissipated and fail to come up in the immediate vicinity of the pile, the utility of the jet is uncertain, except for a part of the penetration.

(8) A steam or drop hammer should be used in connection with the water jet, and used to test the final rate of penetration.

(9) The use of the water jet is one of the most effective means of avoiding injury to piles by overdriving.

(10) There is danger from overdriving when the hammer begins to bounce. Overdriving is also indicated by the bending, kicking or staggering of the pile.

(11) The brooming of the head of the pile dissipates a part, and in some cases all, of the energy due to the fall of the hammer.

(12) The steam hammer is usually more effective than the drop hammer in securing the penetration of a wooden pile without injury, because of the shorter interval between blows.

(13) Where shock to surrounding material is apt to prove detrimental to the structure, the steam hammer should always be used instead of the drop hammer. This is especially true in the case of sheet piling which is intended to prevent the passage of water. In some cases also the jet should not be used.

(14) In general, the resistance of piles, penetrating soft material, depending solely upon skin friction, is materially increased after a period of rest. This period may be as short as fifteen minutes, and rarely exceeds twelve hours.

(15) Where a pile penetrates muck or a soft yielding material and bears upon a hard stratum at its foot, its strength should be determined as a column or beam; omitting the resistance, if any, due to skin friction.

(16) Unless the record of previous experience at the same site is available, the approximate bearing power may be obtained by loading test piles. The results of loading test piles should be used with caution, unless their condition is fairly comparable with that of the piles in the proposed foundation.

(17) In case the piles in a foundation are expected to act as columns, the results of loading test piles should not be depended upon

unless they are sufficient in number to insure their action in a similar manner; and unless they are stayed against lateral motion.

(18) Before testing the penetration of a pile in soft material where its bearing power depends principally, or wholly, upon skin friction, the pile should be allowed to rest for 24 hours after driving.

(19) Where the resistance of piles depends mainly upon skin friction it is possible to diminish the combined strength, or bearing capacity, of a group of piles by driving additional piles within the same area.

(20) Where piles will foot in a hard stratum, investigation should be made to determine that this stratum is of sufficient depth and strength to carry the load.

(21) Timber piles may be advantageously pointed, in some cases, to a 4-inch or 6-inch square at the end.

(22) Piles should not be pointed when driven into soft material.

(23) Shoes should be provided for piles when the driving is very hard, especially in riprap or shale. These shoes should be so constructed as to form an integral part of the pile.

(24) The use of a cap is advantageous in distributing the impact of the hammer more uniformly over the head of the pile, as well as in holding it in position during driving.

[13] WORKING UNIT-STRESSES FOR STRUCTURAL TIMBER EXPRESSED IN POUNDS PER SQUARE INCH.

NOTE.—The working unit-stresses given in this table are intended for railroad bridges and trestles. For highway bridges and trestles the unit-stresses may be increased twenty-five (25) per cent. For buildings and similar structures, in which the timber is protected from the weather and practically free from impact, the unit-stresses may be increased fifty (50) per cent. To compute the deflection of a beam under long-continued loading instead of that when the load is first applied, only fifty (50) per cent of the corresponding modulus of elasticity given in the table is to be employed.

KIND OF TIMBER.	BENDING.			SHEARING.				COMPRESSION.						Ratio of Length of Stringer to Depth.
	Extreme Fiber Stress.		Modulus of Elasticity.	Parallel to the Grain.		Longitudinal Shear in Beams.		Perpendicular to the Grain.		Parallel to the Grain.		For Columns under 15 Diams. Working Stress.	Formulas for Working Stress in Long Columns over 15 Diameters.	
	Average Ultimate	Working Stress	Average	Average Ultimate	Working Stress	Average Ultimate	Working Stress	Elastic Limit	Working Stress	Average Ultimate	Working Stress			
Douglas Fir	6100	1200	1 510 000	690	170	270	110	630	310	3600	1200	900	$1200(1-l/60d)$	10
Longleaf Pine	6500	1300	1 610 000	720	180	300	120	520	260	3800	1300	980	$1300(1-l/60d)$	10
Shortleaf Pine	5600	1100	1 480 000	710	170	330	130	340	170	3400	1100	830	$1100(1-l/60d)$	10
White Pine	4400	900	1 130 000	400	100	180	70	290	150	3000	1000	750	$1000(1-l/60d)$	10
Spruce	4800	1000	1 310 000	600	150	170	70	370	180	3200	1100	830	$1100(1-l/60d)$	
Norway Pine	4200	800	1 190 000	590*	130	250	100	—	150	2600*	800	600	$800(1-l/60d)$	
Tamarack	4600	900	1 220 000	670	170	260	100	—	220	3200*	1000	750	$1000(1-l/60d)$	
Western Hemlock	5800	1100	1 480 000	630	160	270*	100	440	220	3500	1200	900	$1200(1-l/60d)$	
Redwood	5000	900	800 000	300	80	—	—	400	150	3300	900	680	$900(1-l/60d)$	
Bald Cypress	4800	900	1 150 000	500	120	—	—	340	170	3900	1100	830	$1100(1-l/60d)$	
Red Cedar	4200	800	800 000	—	—	—	—	470	230	2800	900	680	$900(1-l/60d)$	
White Oak	5700	1100	1 150 000	840	210	270	110	920	450	3500	1300	980	$1300(1-l/60d)$	12

These unit-stresses are for a green condition of timber and are to be used without increasing the live load stresses for impact.

*Partially air-dry.

l = Length in inches.
d = Least side in inches.

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[13] Adopted, Vol. 10, 1909, pp. 537, 564, 609-611.

[14] PILE RECORD FORM.

Size 8x13 inches. Form M. W. 701.

A. B. & C. R. R. Co.

Pile Record of Bridge..

LOCATION..

Weight and Kind of Hammer.......................................**Date**..............**19**....

Bents Numbered from North or East End **Piles numbered from Left to Right**

Date	Bent No.	No. of Pile	Size of Pile			Kind of Wood	Cut-off	Base-rail to Ground	Total Penetrat.	Av. Last Five Blows		Kind of Soil	Remarks
			Tip End	Butt End	Length					Drop of Ham'r	Penetrat.		

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[14] Adopted, Vol. 12, Part 1, 1911, pp. 278, 307.

[15] USE OF GUARD-RAILS FOR WOODEN BRIDGES AND TRESTLES.

(1) It is recommended as good practice to use guard timbers on all open-floor bridges, and same should be so constructed as to properly space the ties and hold them securely in their places.

(2) It is recommended that the guard timber and the inner guard-rail, when used, shall be so spaced in reference to the track rail that the rear truck will strike the inner guard-rail without striking the guard timber. The inner guard-rail should not be higher or over one inch lower than the running rail.

(3) It is recommended as good practice in the installation of inner guard-rails to extend them beyond the ends of the bridges for such distance as is required by local conditions, but that this distance, in any case, be not less than 50 feet; that inner guard-rails be fully spiked to every tie, and spliced at every joint; that the inner guard-rails be some form of metal section; and that the ends be beveled, bent down, or otherwise protected against direct impact with moving parts of equipment.

(4) It is recommended as good practice to use inner guard-rails on all open-floor and on the outside tracks of all solid-floor bridges and similar structures longer than 20 feet in main-line tracks, and on similar bridges and structures in branch-line tracks on which the speed of trains is 20 miles per hour or more.

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[15] Adopted, Vol. 14, 1913, pp. 652, 653, 1136-1143; Vol. 15, 1914, pp. 403, 1036-1044.

COMMITTEE VIII.

MASONRY.

[1] CLASSIFICATION OF MASONRY.

Kind.	Material.	Description.	Manner of Work.	Dressing.	
				Joints or Beds.	Face or Surface.
Bridge and Retaining Wall.	Stone	Dimension	Coursed	Smooth	Smooth Rock-faced
		Ashlar	Coursed Broken-coursed	Smooth Fine pointed Rough p'ted	Smooth Rock-faced
		Rubble	Uncoursed	Rough p'ted Scabbled	Rock-faced
	Concrete	Reinforced Plain Rubble			
Arch	Stone	Ashlar	Coursed	Smooth Fine pointed	Smooth Rock-faced
		Rubble	Uncoursed	Rough p'ted Scabbled	Rock-faced
	Concrete	Reinforced Plain			
	Brick	No. 1	English Bond Flemish Bond		
Culvert	Stone	Rubble Dry	Uncoursed	Rough p'ted Scabbled	Rock-faced
	Concrete	Reinforced Plain Rubble			
Dry	Stone	Rubble	Uncoursed		

[1] DEFINITIONS.

Masonry, Bridge and Retaining Wall.—Masonry of stone or concrete, designed to carry the end of a bridge span or to retain the abutting earth, or both.

Masonry, Arch.—That portion of the masonry in the arch ring only, or between the intrados and the extrados.

Masonry, Culvert.—Masonry structure of stone or concrete, designed to sustain the fill above and to permit of the free passage of water.

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[1] Adopted, Vol. 7, 1906, pp. 596-601, 619; Vol. 12, Part 1, 1911, pp. 478, 579.

Masonry, Dry.—Masonry in which stones are built up without the use of mortar.

CONCRETE.

Concrete.—A compact mass of broken stone, gravel or other suitable material assembled together with cement mortar and allowed to harden.

Reinforced Concrete.—Concrete in which steel or other metal is embedded in such a manner that both concrete and metal act in unison to resist stresses.

Rubble Concrete.—Concrete in which rubble stone are embedded.

BRICK.

Brick.—No. 1.—Hard burned brick, absorption not exceeding 15 per cent. by weight.

CEMENT.

Cement.—A material of one of the three classes, Portland, Natural and Puzzolan, possessing the property of hardening into a solid mass when mixed with water.

Portland Cement.—This term shall be applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3 per cent. has been made subsequent to calcination.

Natural Cement.—This term shall be applied to the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Puzzolan Cement, as Made in North America.—An intimate mixture obtained by finely pulverizing together granulated basic blast furnace slag and slacked lime.

COURSES AND BOND.

Coursed.—Laid with continuous bed joints.

Broken Coursed.—Laid with parallel, but not continuous, bed joints.

Uncoursed.—Laid without regard to courses.

English Bond.—That disposition of bricks in a structure in which each course is composed entirely of headers or of stretchers.

Flemish Bond.—That disposition of bricks in a structure in which the headers and stretchers alternate in each course, the header being so placed that the outer end lies on the middle of a stretcher in the course below.

Dressing.

DRESSING.—The finish given to the surface of stones or concrete.

SMOOTH.—Having surface, the variations of which do not exceed one-sixteenth inch from the pitch line.

FINE POINTED.—Having irregular surface, the variations of which do not exceed one-quarter inch from the pitch line.

ROUGH POINTED.—Having irregular surface, the variations of which do not exceed one-half inch from the pitch line.

SCABBLED.—Having irregular surface, the variations of which do not exceed three-quarters inch from the pitch line.

ROCK-FACED.—Presenting irregular projecting face, without indications of tool mark.

Descriptive Words.

ABUTMENT.—A supporting wall carrying the end of a bridge or span and sustaining the pressure of the abutting earth. The abutment of an arch is commonly called a bench wall.

ARRIS.—The external edge formed by two surfaces, whether plain or curved, meeting each other.

ASHLAR.—A squared or cut block of stone of rectangular dimensions.

BACKING.—That portion of a masonry wall or structure built in the rear of the face. It must be attached to the face and bonded with it. It is usually of a cheaper grade of work than the face.

BATTER.—The slope or inclination of the face or back of a wall from a vertical plane.

BED.—The top or bottom of a stone. (See Course Bed; Natural Bed; Foundation Bed.)

BED JOINT.—A horizontal joint, or one perpendicular to the line of pressure.

BENCH WALL.—The abutment from which an arch springs.

BOND.—In stone or brick masonry, the mechanical disposition of stone, brick or other building blocks by overlapping to break joints.

BUILD.—A vertical joint.

CENTERING.—A temporary support used in arch construction. (Also called centers.)

CLAMP.—An instrument for lifting stone so designed that its grip on the surface of the stone is increased as the load is applied. That portion engaging the stone is of wood attached to a steel shoe, which in turn is hinged to the shank of the clamp in such a manner as to adjust itself to the surface of the body lifted.

Coping.—A top course of stone or concrete, generally slightly projecting, to shelter the masonry from the weather, or to distribute the pressure from exterior loading.

Course.—Each separate layer in stone, concrete or brick masonry.

Course Bed.—Stone, brick or other building material in position, upon which other material is to be laid.

Cramps.—Bars of iron having the ends turned at right angles to the body of the bar which enter holes in the upper side of adjacent stones.

Culvert.—A covered passage for water under a roadway or embankment.

Dimension Stone.—A block of stone cut to specified dimensions.

Dowels.—(a) Metal bars used to connect two sections of masonry.

Dowel.—(b) A two-piece steel instrument used in lifting stone. The dowel engages the stone by means of two holes drilled into the stone at an angle of about 45 degrees pointing toward each other. The dowel is not keyed in place.

Draft.—A line on the surface of a stone cut to the breadth of the chisel.

Expansion Joint.—A vertical joint or space to allow for temperature changes.

Extrados.—The outer or convex surface of an arch.

Face.—The exposed surface in elevation.

Facing.—In concrete: Mortar on the exposed surface for finish.

Final Set.—A stage of the process of setting marked by certain hardness. (See Cement Specifications.)

Flush (Adj.).—Having the surface even or level with an adjacent surface.

Flush (Verb).—(1) To fill. (2) To bring to a level. (3) To force water to the surface of mortar or concrete by compacting or ramming.

Footing.—A bottom course.

Form.—A temporary structure in which to cast concrete.

Foundation.—(1) That portion of a structure usually below the surface of the ground, which distributes the pressure upon its support. (2) Also applied to the natural support itself; rock, clay, etc.

Foundation Bed.—The surface on which a structure rests.

Grout.—A mortar of liquid consistency which can easily be poured.

Header.—A stone which has its greatest length at right angles to the face of the wall, and which bonds the face stones to the backing.

Initial Set.—An early stage of the process of setting, marked by certain hardness. (See Cement Specifications.)

Intrados.—The inner or concave surface of an arch.

Joint.—The narrow space between adjacent stones, bricks or other building blocks, usually filled with mortar.

Lagging.—Strips used to carry and distribute the weight of an arch to the ribs or centering during its construction.

Laitance.—A sediment from cement of concrete deposited in water, or of concrete, when water is worked to the surface.

Lewis.—A four-piece steel instrument used in lifting stone. (The lewis engages the stone by means of a triangular-shaped hole into which it is keyed.)

Lock.—Any special device or method of construction used to secure a bond in the work.

Mortar.—A mixture of fine aggregate, cement or lime and water used to bind together the materials of concrete, stone or brick in masonry or to cover the surface of the same.

Natural Bed.—The surfaces of a stone parallel to its stratification.

Parapet.—A wall or barrier on the edge of an elevated structure for protection or ornament.

Paving.—Regularly placed stone or brick forming a floor.

Pier.—An intermediate support for arches or other spans.

Pitch (Verb).—To square a stone.

Pitched.—Having the arris clearly defined by a line beyond which the rock is cut away by the pitching chisel so as to make approximately true edges.

Pointing.—Filling joints or defects in the face of a masonry structure.

Retaining Wall.—A wall for sustaining the pressure of earth or filling deposited behind it.

Ring Stones.—The end voussoirs of an arch.

Riprap.—Rough stone of various sizes placed compactly or irregularly to prevent scour by water.

Rubble.—Field stone or rough stone as it comes from the quarry. When it is of a large or massive size it is termed block rubble.

Rubbed.—A fine finish made by rubbing with grit or sandstone.

Set (Noun).—The change from a plastic to a solid or hard state.

Slope Wall.—A wall to protect the slope of an embankment or cut.

Soffit.—The under side of a projection.

Spall (Noun).—A chip or small piece of stone broken from a large block.

Spandrel Wall.—The wall at the end of an arch above the springing line and extrados of the arch and below the coping or the string course.

STRETCHER.—A stone which has its greatest length parallel to the face of the wall.

TREMIE.—A cylindrical or other form of tube, with sloped top or pocket used for depositing concrete in water.

VOUSSOIRS.—The individual stones forming an arch. They are always of truncated wedge form.

WING WALL.—An extension of an abutment wall to retain the adjacent earth.

[2] MASONRY.

GENERAL DEFINITION.

The following is a comprehensive definition to cover any kind of masonry, given with the recommendation that in usual practice the word "masonry" be qualified by some proper term to more particularly describe the kind of masonry under consideration:

Masonry, in its widest sense, includes all construction of stone or kindred substitute materials, in which the separate pieces are either placed together, with or without cementing material to join them; or encased in a matrix of firmly cementing material.

[3] MASONRY SPECIFICATIONS.

It is recommended that railway companies prepare and use specifications complete in themselves for all kinds of masonry, in such form that they may be attached to and form part of specifications and contracts for other railway construction when desirable.

[4] SPECIFICATIONS FOR NATURAL AND PORTLAND CEMENT.

(Standard Specifications for Cement adopted by a Joint Committee, embracing representatives from the American Society of Civil Engineers, American Society for Testing Materials, American Institute of Architects, Engineer Department of United States Army, Association of Portland Cement Manufacturers, and American Railway Engineering Association.)

GENERAL OBSERVATIONS.

1. These remarks have been prepared with a view to pointing out the pertinent features of the various requirements and the precautions to be observed in the interpretation of the results of the tests.

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[2] Adopted, Vol. 3, 1902, pp. 310, 347.

[3] Adopted, Vol. 3, 1902, pp. 310, 348.

[4] Adopted, Vol. 4, 1903, pp. 389-436, 443; Vol. 5, 1904, pp. 605-610; Vol. 6, 1905, pp. 704-718, 723, 724, 726-728; Vol. 11, 1910, pp. 956, 957, 958.

2. It is suggested that the acceptance or rejection under these specifications be based on tests made by an experienced person having the proper means for making the tests.

Specific Gravity.

3. Specific gravity is useful in detecting adulteration or underburning. The results of tests of specific gravity are not necessarily conclusive as an indication of the quality of a cement; but when in combination with the results of other tests they may afford valuable indications.

Fineness.

4. The sieves should be kept thoroughly dry.

Time of Setting.

5. Great care should be exercised to maintain the test pieces under as uniform conditions as possible. A sudden change or wide range of temperature in the room in which the tests are made, a very dry or humid atmosphere, or other irregularities vitally affect the rate of setting.

Tensile Strength.

6. Each consumer should fix the minimum requirements for tensile strength to suit his own conditions. They should, however, be within the limits stated.

Constancy of Volume.

7. The tests for constancy of volume are divided into two classes, the first normal, the second accelerated. The latter should be regarded as a precautionary test only, and not infallible. So many conditions enter into the making and interpreting of it that it should be used with extreme care.

8. In making the pats the greatest care should be exercised to avoid initial strains due to molding or too rapid drying out during the first twenty-four hours. The pats should be preserved under the most uniform conditions possible, and rapid changes of temperature should be avoided.

9. Failure to meet the requirements of the accelerated tests need not be sufficient cause for rejection. The cement may, however, be held for twenty-eight days, and a retest made at the end of that period. Failure to meet the requirements at this time should be considered sufficient cause for rejection, although in the present state of knowledge it cannot be said that such failure necessarily indicates unsoundness, nor can the cement be considered entirely satisfactory simply beause it passes the tests.

STANDARD SPECIFICATIONS FOR CEMENT.

GENERAL CONDITIONS.

1. All cement shall be inspected.

2. Cement may be inspected either at the place of manufacture or on the work.

3. In order to allow ample time for inspecting and testing, the cement shall be stored in a suitable weather-tight building having the floor properly blocked or raised from the ground.

4. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

5. Every facility shall be provided by the contractor and a period of at least twelve days allowed for the inspection and necessary tests.

6. Cement shall be delivered in suitable packages with the brand and name of manufacturer plainly marked thereon.

7. A bag of cement shall contain 94 lbs. of cement net. Each barrel of Portland cement shall contain four bags, and each barrel of Natural cement shall contain three bags of the above net weight.

8. Cement failing to meet the seven-day requirements may be held awaiting the results of the twenty-eight-day tests before rejection.

9. Tests shall be made in accordance with the methods proposed by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, presented to the Society January 21, 1903, and amended January 20, 1904, with all subsequent amendments thereto. (See addendum to these specifications.)

10. Acceptance or rejection shall be based on the following requirements:

NATURAL CEMENT.

Definition.

11. This term shall be applied to the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Specific Gravity.

12. The specific gravity of the cement, thoroughly dried at 100 degrees Cent., shall not be less than 2.8.

Fineness.

13. It shall leave by weight a residue of not more than 10 per cent. on the No. 100, and 30 per cent. on the No. 200 sieve.

Time of Setting.

14. It shall develop initial set in not less than ten minutes, and hard set in not less than thirty minutes, nor more than three hours.

Tensile Strength.

15. The minimum requirements for tensile strength for briquettes one inch square in cross-section shall be as follows, and shall show no retrogression in strength within the periods specified:*

Age.	Strength.
Neat Cement.	
24 hours in moist air	75 lbs.
7 days (1 day in moist air, 6 days in water)	150 lbs.
28 days (1 day in moist air, 27 days in water)	250 lbs.
One Part Cement, Three Parts Standard Ottawa Sand.	
7 days (1 day in moist air, 6 days in water)	50 lbs.
28 days (1 day in moist air, 27 days in water)	125 lbs.

Constancy of Volume.

16. Pats of neat cement about three inches in diameter, one-half inch thick at center, tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air of normal temperature.

(b) Another is kept in water maintained as near 70 degrees Fahrenheit as practicable.

17. These pats are observed at intervals for at least 28 days, and, to satisfactorily pass the tests, should remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

PORTLAND CEMENT.

Definition.

18. This term shall be applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3 per cent. has been made subsequent to calcination.

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* For example, the minimum requirement for the twenty-four hour neat cement tests should show some specified value within the limits of 50 and 100 pounds, and so on for each period stated.

Specific Gravity.

19. The specific gravity of cement shall not be less than 3.10. Should the tests of cement as received fall below this requirement, a second test may be made upon a sample ignited at a low red heat. The loss in weight of the ignited cement shall not exceed 4 per cent.

Fineness.

20. It shall leave by weight a residue of not more than 8 per cent. on the No. 100, and not more than 25 per cent. on the No. 200 sieve.

Time of Setting.

21. It shall develop initial set in not less than thirty minutes, but must develop hard set in not less than one hour, nor more than ten hours.

Tensile Strength.

22. The minimum requirements for tensile strength for briquettes one inch square in cross-section shall be as follows, and shall show no retrogression in strength within the periods specified:*

Age.	Strength.
Neat Cement.	
24 hours in moist air	175 lbs.
7 days (1 day in moist air, 6 days in water)	500 lbs.
28 days (1 day in moist air, 27 days in water)	600 lbs.
One Part Cement, Three Parts Standard Ottawa Sand.	
7 days (1 day in moist air, 6 days in water)	200 lbs.
28 days (1 day in moist air, 27 days in water)	275 lbs.

Constancy of Volume.

23. Pats of neat cement about three inches in diameter, one-half inch thick at the center, and tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air at normal temperature and observed at intervals for at least 28 days.

(b) Another pat is kept in water maintained as near 70 degrees Fahrenheit as practicable and observed at intervals for at least 28 days.

(c) A third pat is exposed in any convenient way in an atmosphere of steam above boiling water, in a loosely closed vessel for five hours.

24. These pats, to satisfactorily pass the requirements, shall remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

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* For example, the minimum requirement for the twenty-four hour neat cement test should show some specified value within the limits of 150 and 200 pounds, and so on for each period stated.

Sulphuric Acid and Magnesia.

25. The cement shall not contain more than 1.75 per cent. of anhydrous sulphuric acid (SO_3), nor more than 4 per cent. of magnesia (MgO).

ADDENDUM.

REPORT OF THE SPECIAL COMMITTEE ON UNIFORM TESTS OF CEMENT.

Authorized Reprint from the Copyrighted Proceedings of the American Society of Civil Engineers, pp. 105-118, February, 1911.

SAMPLING.

Selection of Sample.

1. The selection of the sample for testing is a detail that must be left to the discretion of the Engineer; the number and the quantity to be taken from each package will depend largely on the importance of the work, the number of tests to be made and the facilities for making them.

2. The sample shall be a fair average of the contents of the package; it is recommended that, where conditions permit, one barrel in every ten be sampled.

3. Samples should be passed through a sieve having twenty meshes per linear inch, in order to break up lumps and remove foreign material; this is also a very effective method for mixing them together in order to obtain an average. For determining the characteristics of a shipment of cement, the individual samples may be mixed and the average tested; where time will permit, however, it is recommended that they be tested separately.

Method of Sampling.

4. Cement in barrels should be sampled through a hole made in the center of one of the staves, midway between the heads, or in the head, by means of an auger or a sampling iron similar to that used by sugar inspectors. If in bags, it should be taken from surface to center.

CHEMICAL ANALYSIS.

Significance.

5. Chemical analysis may render valuable service in the detection of adulteration of cement with considerable amounts of inert material, such as slag or ground limestone. It is of use, also, in determining whether certain constituents, believed to be harmful when in excess of

a certain percentage, as magnesia and sulphuric anhydride, are present in inadmissible proportions.

6. The determination of the principal constituents of cement—silica, alumina, iron oxide and lime—is not conclusive as an indication of quality. Faulty character of cement results more frequently from imperfect preparation of the raw material or defective burning than from incorrect proportions of the constituents. Cement made from very finely ground material and thoroughly burned may contain much more lime than the amount usually present, and still be perfectly sound. On the other hand, cements low in lime may, on account of careless preparation of the raw material, be of dangerous character. Further, the ash of the fuel used in burning may so greatly modify the composition of the product as largely to destroy the significance of the results of analysis.

Method.

7. As a method to be followed for the analysis of cement, that proposed by the Committee on Uniformity in the Analysis of Materials for the Portland Cement Industry, of the New York Section of the Society for Chemical Industry, and published in Engineering News, Vol. 50, p. 60, 1903, and in Engineering Record, Vol. 48, p. 49, 1903, is recommended.

SPECIFIC GRAVITY.

Significance.

8. The specific gravity of cement is lowered by adulteration and hydration, but the adulteration must be in considerable quantity to affect the results appreciably.

9. Inasmuch as the differences in specific gravity are usually very small, great care must be exercised in making the determination.

Apparatus and Method.

10. The determination of specific gravity is most conveniently made with Le Chatelier's apparatus. This consists of a flask (*D*), Fig. 1, of 120 cubic cm. (7.32 cubic inches) capacity, the neck of which is about 20 cm. (7.87 inches) long; in the middle of this neck is a bulb (*C*), above and below which are two marks (*F*) and (*E*); the volume between these marks is 20 cubic cm. (1.22 cubic inches). The neck has a diameter of about 9 mm. (0.35 inches), and is graduated into tenths of cubic centimeters above the mark (*F*).

11. Benzine (62 degrees Baumé naphtha), or kerosene free from water, should be used in making the determination.

12. The specific gravity is determined as follows:

The flask is filled with either of these liquids to the lower mark (*E*), and 64 g. (2.25 oz.) of powder, cooled to the temperature of the liquid, is gradually introduced through the funnel (*B*), the stem of which extends into the flask to the top of the bulb (*C*), until all the powder is introduced, and the level of the liquid rises to some division of the graduated neck. This reading plus 20 cubic cm. is the volume displaced by 64 g. of the powder.

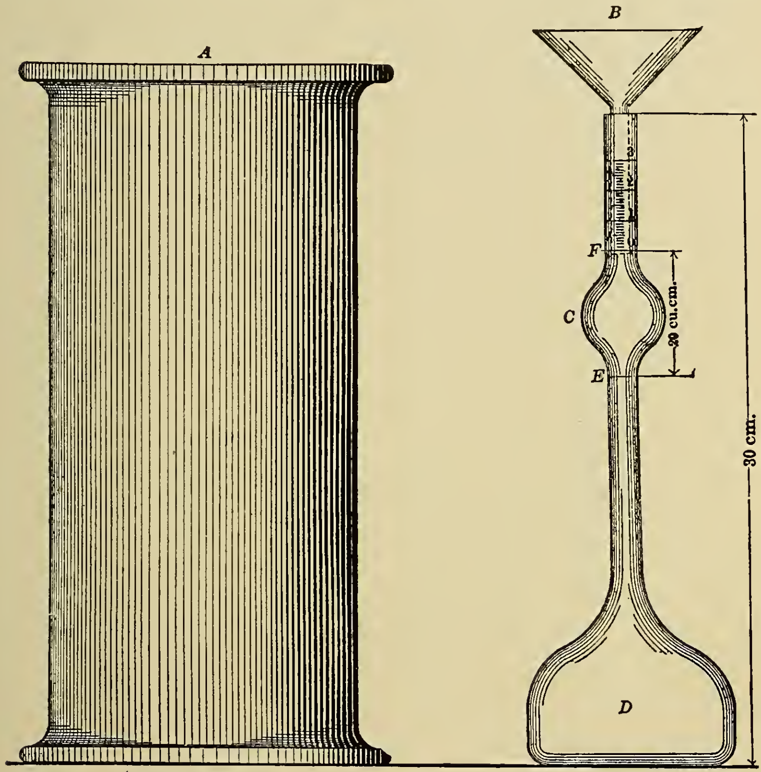

FIG. 1. LE CHATELIER'S SPECIFIC GRAVITY APPARATUS.

13. The specific gravity is then obtained from the formula:

$$\text{Specific Gravity} = \frac{\text{Weight of Cement, in grammes.}}{\text{Displaced Volume, in cubic centimeters.}}$$

14. The flask, during the operation, is kept immersed in water in a jar (*A*), in order to avoid variations in the temperature of the liquid.

The results should agree within 0.01. The determination of specific gravity should be made on the cement as received; and, should it fall below 3.10, a second determination should be made on the sample ignited at a low red heat.

15. A convenient method for cleaning the apparatus is as follows: The flask is inverted over a large vessel, preferably a glass jar, and shaken vertically until the liquid starts to flow freely; it is then held still in a vertical position until empty; the remaining traces of cement can be removed in a similar manner by pouring into the flask a small quantity of clean liquid benzine or kerosene and repeating the operation.

FINENESS.

Significance.

16. It is generally accepted that the coarser particles in cement are practically inert, and it is only the extremely fine powder that possesses adhesive or cementing qualities. The more finely cement is pulverized, all other conditions being the same, the more sand it will carry and produce a mortar of a given strength.

17. The degree of final pulverization which the cement receives at the place of manufacture is ascertained by measuring the residue retained on certain sieves. Those known as the No. 100 and No. 200 sieves are recommended for this purpose.

Apparatus.

18. The sieves should be circular, about 20 cm. (7.87 inches) in diameter, 6 cm. (2.36 inches) high, and provided with a pan 5 cm. (1.97 inches) deep, and a cover.

19. The wire cloth should be of brass wire having the following diameter:

No. 100, 0.0045 inches; No. 200, 0.0024 inches.

20. This cloth should be mounted on the frames without distortion; the mesh should be regular in spacing and be within the following limits:

No. 100, 96 to 100 meshes to the linear inch.
No. 200, 188 to 200 meshes to the linear inch.

21. Fifty grammes (1.76 oz.) or 100 g. (3.52 oz.) should be used for the test, and dried at a temperature of 100 degrees Centigrade (212 degrees Fahrenheit) prior to sieving.

Method.

22. The thoroughly dried and coarsely screened sample is weighed and placed on the No. 200 sieve, which, with pan and cover attached, is held in one hand in a slightly inclined position, and moved forward and

backward, at the same time striking the side gently with the palm of the other hand, at the rate of about 200 strokes per minute. The operation is continued until not more than one-tenth of 1 per cent. passes through after one minute of continuous sieving. The residue is weighed, then placed on the No. 100 sieve and the operation repeated. The work may be expedited by placing in the sieve a small quantity of large steel shot. The results should be reported to the nearest tenth of 1 per cent.

NORMAL CONSISTENCY.

Significance.

23. The use of a proper percentage of water in making the pastes* from which pats, tests of setting and briquettes are made, is exceedingly important, and affects vitally the results obtained.

24. The determination consists in measuring the amount of water required to reduce the cement to a given state of plasticity, or to what is usually designated the normal consistency.

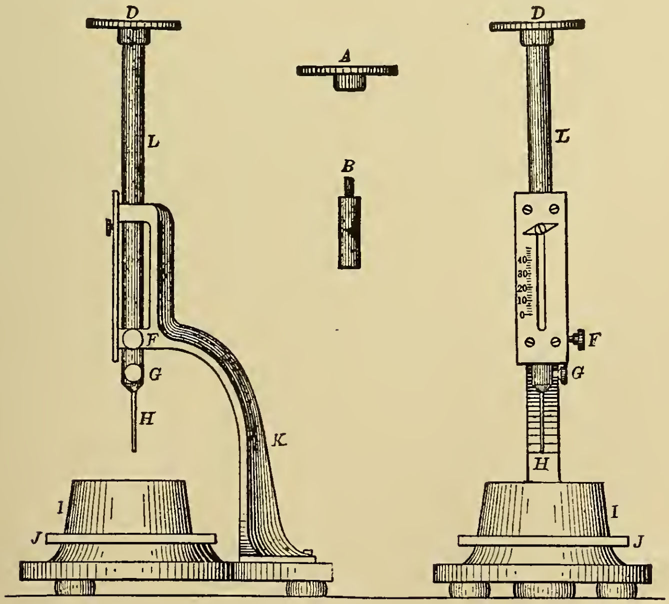

Fig. 2. Vicat Needle.

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* The term "paste" is used in this report to designate a mixture of cement and water, and the word "mortar" a mixture of cement, sand and water.

25. The Committee recommends the following method for determining normal consistency:

Method.

26. This can best be determined by means of *Vicat Needle Apparatus,* which consists of a frame (*K*), Fig. 2, bearing a movable rod (*L*), with the cap (*A*) at one end, and at the other the cylinder (*B*), 1 cm. (0.39 inches) in diameter, the cap, rod and cylinder weighing 300 g. (10.58 oz.). The rod, which can be held in any desired position by a screw (*F*), carries an indicator, which moves over a scale (graduated to centimeters) attached to the frame (*K*). The paste is held by a conical hard-rubber ring (*I*), 7 cm. (2.76 inches) in diameter at the base, 4 cm. (1.57 inches) high, resting on a glass plate (*J*), about 10 cm. (3.94 inches) square.

27. In making the determination, the same quantity of cement as will be subsequently used for each batch in making the briquettes [but not less than 500 g. (17.16 oz.)] is kneaded into a paste, as described in paragraph 52, and quickly formed into a ball with the hands, completing the operation by tossing it six times from one hand to the other, maintained 6 inches apart; the ball is then pressed into the rubber ring, through the larger opening, smoothed off and placed (on its large end) on a glass plate and the smaller end smoothed off with a trowel; the paste, confined in the ring, resting on the plate, is placed under the rod bearing the cylinder, which is brought in contact with the surface and quickly released.

28. The paste is of normal consistency when the cylinder in one minute from the time it is released penetrates to a point in the mass 10 mm. (0.39 inches) below the top of the ring. Great care must be taken to fill the ring exactly to the top. The apparatus must be free from all vibrations during the test.

29. The trial pastes are made with varying percentages of water until the correct consistency is obtained.

30. The Committee has recommended, as normal, a paste, the consistency of which is rather wet, because it believes that variations in the amount of compression to which the briquette is subjected in molding are likely to be less with such a paste.

31. Having determined in this manner the proper percentage of water required to produce a paste of normal consistency, the proper percentage required for the mortars is obtained from the following table:

PERCENTAGE OF WATER FOR STANDARD SAND MORTARS.

Neat.	One Cement Three Standard Ottawa Sand.	Neat	One Cement Three Standard Ottawa Sand.	Neat.	One Cement Three Standard Ottawa Sand.
15	8.0	23	9.3	31	10.7
16	8.2	24	9.5	32	10.8
17	8.3	25	9.7	33	11.0
18	8.5	26	9.8	34	11.2
19	8.7	27	10.0	35	11.5
20	8.8	28	10.2	36	11.5
21	9.0	29	10.3	37	11.7
22	9.2	30	10.5	38	11.8

TIME OF SETTING.

Significance.

32. The object of this test is to determine the time which elapses from the moment water is added until the paste ceases to be fluid and plastic (called the "initial set"), and also the time required for it to acquire a certain degree of hardness (called the "final" or "hard set"). The former of these is the more important, since, with the commencement of setting, the process of crystallization or hardening is said to begin. As a disturbance of this process may produce a loss of strength, it is desirable to complete the operation of mixing and molding or incorporating the mortar into the work before the cement begins to set.

33. It is usual to measure arbitrarily the beginning and end of the setting by the penetration of weighted wires of given diameters.

Method.

34. For this purpose the Vicat Needle, which has already been described in paragraph 26, should be used.

35. In making the test, a paste of normal consistency is molded and placed under the rod (*L*), Fig. 2, as described in paragraph 27; this rod, bearing the cap (*D*) at one end and the needle (*H*), 1 mm. (0.039 inches) in diameter, at the other, weighing 300 g. (10.58 oz.). The needle is then carefully brought in contact with the surface of the paste and quickly released.

36. The setting is said to have commenced when the needle ceases to pass a point 5 mm. (0.20 inches) above the upper surface of the glass plate, and is said to have terminated the moment the needle does not sink visibly into the mass.

37. The test pieces should be stored in moist air during the test; this is accomplished by placing them on a rack over water contained in a pan and covered with a damp cloth, the cloth to be kept away from

them by means of a wire screen; or they may be stored in a moist box or closet.

38. Care should be taken to keep the needle clean, as the collection of cement on the sides of the needle retards the penetration, while cement on the point reduces the area and tends to increase the penetration.

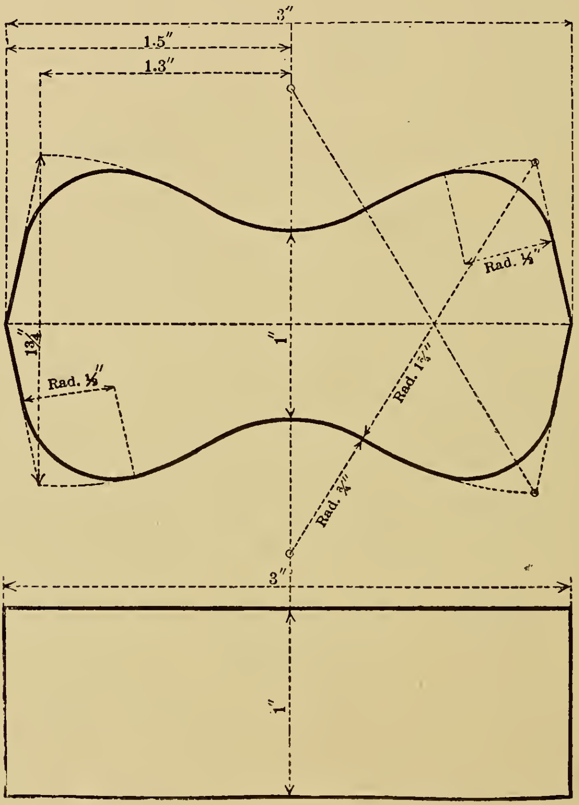

Fig. 3.—Details for Briquette.

39. The determination of the time of setting is only approximate, being materially affected by the temperature of the mixing water, the temperature and humidity of the air during the test, the percentage of water used, and the amount of kneading the paste receives.

STANDARD SAND.

40. For the present, the use of the natural sand from Ottawa, Ill., screened to pass a sieve having 20 meshes per linear inch and retained on a sieve having 30 meshes per linear inch is recommended; the wires to have diameters of 0.0165 and 0.0112 inches, respectively, *i. e.,* half the width of the opening in each case. Sand having passed the No. 20 sieve shall be considered standard when not more than 1 per cent. passes a No. 30 sieve after one minute's continuous sifting of a 500-g. sample.*

FORM OF TEST PIECES.

41. For tension tests the Committee recommends the form of test piece shown in Fig. 3.

42. For compression tests a 2-inch cube is recommended.

MOLDS.

43. The molds should be made of brass, bronze or some equally non-corrosive material, having sufficient metal in the sides to prevent spreading during molding.

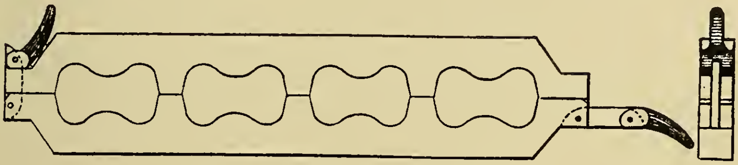

FIG. 4.—DETAILS FOR GANG MOLD.

44. Gang molds, which permit molding a number of briquettes at one time, are preferred by many to single molds; since the greater quantity of mortar that can be mixed tends to produce a greater uniformity in the results. The type shown in Figs. 4 and 5 is recommended.

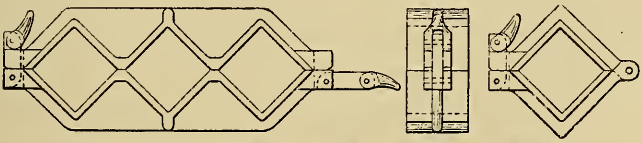

FIG. 5.—MOLD FOR COMPRESSION TEST PIECES.

45. The molds should be wiped with an oily cloth before using.

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* This sand may be obtained from the Ottawa Silica Company at a cost of two cents per pound f. o. b. cars. Ottawa, Ill.

MIXING.

46. All proportions should be stated by weight; the quantity of water to be used should be stated as a percentage of the dry material.

47. The metric system is recommended because of the convenient relation of the gramme and the cubic centimeter.

48. The temperature of the room and the mixing water should be as near 21 degrees Centigrade (70 degrees Fahrenheit) as it is practical to maintain it.

49. The sand and cement should be thoroughly mixed dry. The mixing should be done on some non-absorbing surface, preferably plate glass. If the mixing must be done on an absorbing surface it should be thoroughly dampened prior to use.

50. The quantity of material to be mixed at one time depends on the number of test pieces to be made; about 1000 g. (35.28 oz.) makes a convenient quantity to mix, especially by hand methods.

51. The Committee, after investigation of the various mechanical mixing machines, has decided not to recommend any machine that has thus far been devised, for the following reasons:

(1) The tendency of most cement is to "ball up" in the machine, thereby preventing the working of it into a homogeneous paste; (2) there are no means of ascertaining when the mixing is complete without stopping the machine, and (3) the difficulty of keeping the machine clean.

Method.

52. The material is weighed and placed on the mixing table, and a crater formed in the center, into which the proper percentage of clean water is poured; the material on the outer edge is turned into the crater by the aid of a trowel. As soon as the water has been absorbed, which should not require more than one minute, the operation is completed by vigorously kneading with the hands for an additional 1 minute, the process being similar to that used in kneading dough. A sandglass affords a convenient guide for the time of kneading. During the operation of mixing the hands should be protected by gloves, preferably of rubber.

MOLDING.

53. Having worked the paste or mortar to the proper consistency, it is at once placed in the molds by hand.

54. The Committee has been unable to secure satisfactory results with the present molding machines; the operation of machine molding

is very slow, and the present types permit of molding but one briquette at a time, and are not practicable with the pastes or mortars herein recommended.

Method.

55. The molds should be filled immediately after the mixing is completed, the material pressed in firmly with the fingers and smoothed off with a trowel without mechanical ramming; the material should be heaped up on the upper surface of the mold, and, in smoothing off, the trowel should be drawn over the mold in such a manner as to exert a moderate pressure on the excess material. The mold should be turned over and the operation repeated.

56. A check upon the uniformity of the mixing and molding is afforded by weighing the briquettes just prior to immersion, or upon removal from the moist closet. Briquettes which vary in weight more than 3 per cent. from the average should not be tested.

STORAGE OF THE TEST PIECES.

57. During the first 24 hours after molding, the test pieces should be kept in moist air to prevent them from drying out.

Method.

58. A moist closet or chamber is so easily devised that the use of the damp cloth should be abandoned if possible. Covering the test pieces with a damp cloth is objectionable, as commonly used, because the cloth may dry out unequally, and in consequence the test pieces are not all maintained under the same condition. Where a moist closet is not available, a cloth may be used and kept uniformly wet by immersing the ends in water. It should be kept from direct contact with the test pieces by means of a wire screen or some similar arrangement.

59. A moist closet consists of a soapstone or slate box, or a metal-lined wooden box—the metal lining being covered with felt and this felt kept wet. The bottom of the box is so constructed as to hold water, and the sides are provided with cleats for holding glass shelves on which to place the briquettes. Care should be taken to keep the air in the closet uniformly moist.

60. After 24 hours in moist air, the test pieces for longer periods of time should be immersed in water maintained as near 21 degrees Centigrade (70 degrees Fahrenheit) as practicable; they may be stored in tanks or pans, which should be of non-corrodible material.

TENSILE STRENGTH.

Tensile Strength.

61. The tests may be made on any machine. A solid metal clip, as shown in Fig. 6, is recommended. This clip is to be used without cushioning at the points of contact with the test specimen. The bearing at each point of contact should be ¼-inch wide, and the distance between the centers of contact on the same clip should be 1¼ inches.

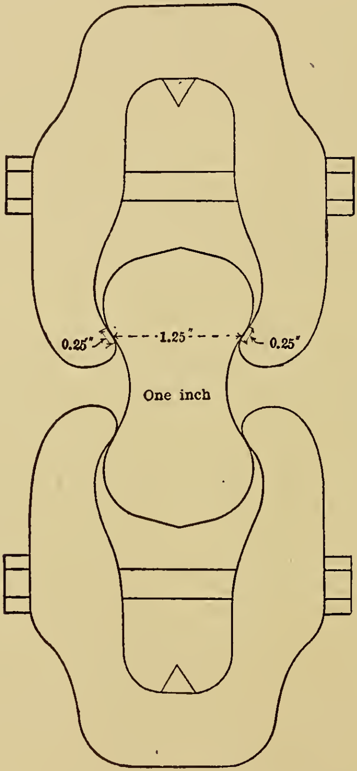

Fig. 6.—Form of Clip.

62. Test pieces should be broken as soon as they are removed from the water. Care should be observed in centering the briquettes in the testing machine, as cross-strains, produced by improper centering, tend to lower the breaking strength. The load should not be applied too suddenly, as it may produce vibration, the shock from which often breaks the briquette before the ultimate strength is reached. Care must

be taken that the clips and the sides of the briquette be clean and free from grains of sand or dirt which would prevent a good bearing. The load should be applied at the rate of 600 lbs. per minute. The average of the briquettes of each sample tested should be taken as the test, excluding any results which are manifestly faulty.

COMPRESSIVE STRENGTH.

63. The tests may be made in any machine provided with a means for so applying the load that the line of pressure is along the axis of the test piece. A ball-bearing block for this purpose is shown in Fig. 7

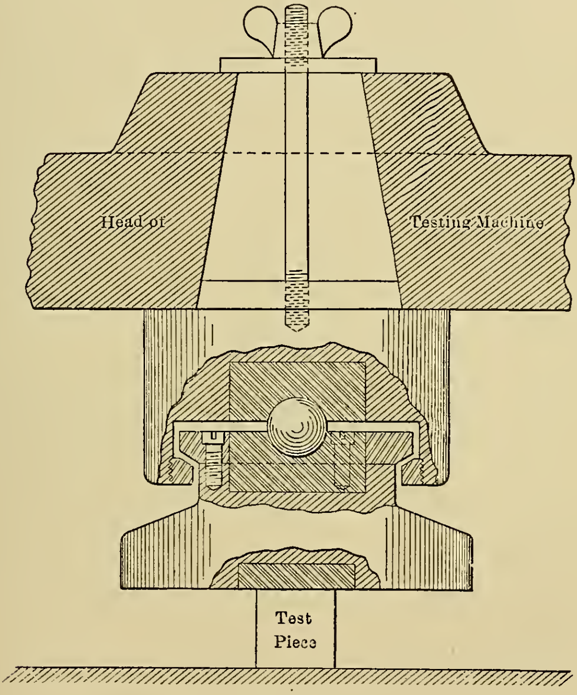

Fig. 7.

64. Some appliance to facilitate placing the center of the ball-bearing exactly in the line of the axis of the test piece should be provided.

The test piece should be placed in the testing machine with a piece of heavy blotting paper on each of the crushing faces, which should be those that were in contact with the mold.

The test piece should be broken as soon as removed from the water.

CONSTANCY OF VOLUME.

Significance.

65. The object is to develop those qualities which tend to destroy the strength and durability of a cement. As it is highly essential to determine such qualities at once, tests of this character are for the most part made in a very short time, and are known, therefore, as accelerated tests. Failure is revealed by cracking, checking, swelling or distintegration, or all of these phenomena. A cement which remains perfectly sound is said to be of constant volume.

Method.

66. Tests for constancy of volume are divided into two classes: (1) Normal tests, or those made in either air or water maintained at about 21 degrees Centigrade (70 degrees Fahrenheit), and (2) accelerated tests, or those made in air, steam or water at a temperature of 45 degrees Centigrade (113 degrees Fahrenheit) and upward. The test pieces should be allowed to remain 24 hours in moist air before immersion in water or steam, or preservation in air.

67. For these tests, pats about 7½ cm. (2.95 inches) in diameter, 1¼ cm. (0.49 inch) thick at the center, and tapering to a thin edge, should be made, upon a clean glass plate [about 10 cm. (3.94 inches) square], from cement paste of normal consistency.

Normal Test.

68. A pat is immersed in water maintained as near 21 degrees Centigrade (70 degrees Fahrenheit) as possible for 28 days, and observed at intervals. A similar pat, after 24 hours in moist air, is maintained in air at ordinary temperature and observed at intervals.

Accelerated Test.

69. A pat is placed in an atmosphere of steam upon a wire screen one inch above boiling water for five (5) hours.

The apparatus should be so constructed as to permit the free escape of steam and maintain atmospheric pressure.

Since the type of apparatus used has a great influence on the uniformity of the results, that shown in Fig. 8 is recommended.

70. To pass these tests satisfactorily, the pats should remain firm and hard, and show no signs of cracking, distortion or disintegration.

71. Should the pat leave the plate, distortion may be detected best with a straight-edge applied to the surface which was in contact with the plate.

72. In the present state of our knowledge it cannot be said that cement should necessarily be condemned simply for failure to pass the

accelerated tests; nor can a cement be considered entirely satisfactory simply because it has passed these tests.

METHOD SUGGESTED FOR THE ANALYSIS OF LIMESTONE, RAW MIXTURES AND PORTLAND CEMENTS BY THE COMMITTEE ON UNIFORMITY IN TECHNICAL ANALYSIS OF THE NEW YORK SECTION SOCIETY FOR CHEMICAL INDUSTRY.

Solution.

One-half gramme of the finely powdered substance is to be weighed out and, if a limestone or unburned mixture, strongly ignited in a covered platinum crucible over a strong blast for fifteen minutes, or longer if the blast is not powerful enough to effect complete conversion to a cement in this time. It is then transferred to an evaporating dish, preferably of platinum for the sake of celerity in evaporation, moistened with enough water to prevent lumping, and 5 to 10 c.c. of strong HCl added and digested with the aid of gentle heat and agitation until solution is complete. Solution may be aided by light pressure with the flattened end of a glass rod.* The solution is then evaporated to dryness, as far as this may be possible on the bath.

Silica (SiO_2).

The residue without further heating is treated at first with 5 to 10 c.c. of strong HCl which is then diluted to half strength or less, or upon the residue may be poured at once a larger volume of acid of half strength. The dish is then covered and digestion allowed to go on for 10 minutes on the bath, after which the solution is filtered and the separated silica washed thoroughly with water. The filtrate is again evaporated to dryness, the residue without further heating, taken up with acid and water and the small amount of silica it contains separated on another filter paper. The papers containing the residue are transferred wet to a weighed platinum crucible, dried, ignited, first over a Bunsen burner until the carbon of the filter is completely consumed, and finally over the blast for 15 minutes and checked by a further blasting for 10 minutes or to constant weight. The silica, if great accuracy is desired, is treated in the crucible with about 10 c.c. of HFl and four drops of H_2SO_4, and evaporated over a low flame to complete dryness. The small residue is finally blasted, for a minute or two, cooled and weighed. The

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* If anything remains undecomposed it should be separated, fused with a little Na_2CO_2, dissolved and added to the original solution. Of course a small amount of separated non-gelatinous silica is not to be mistaken for undecomposed matter.

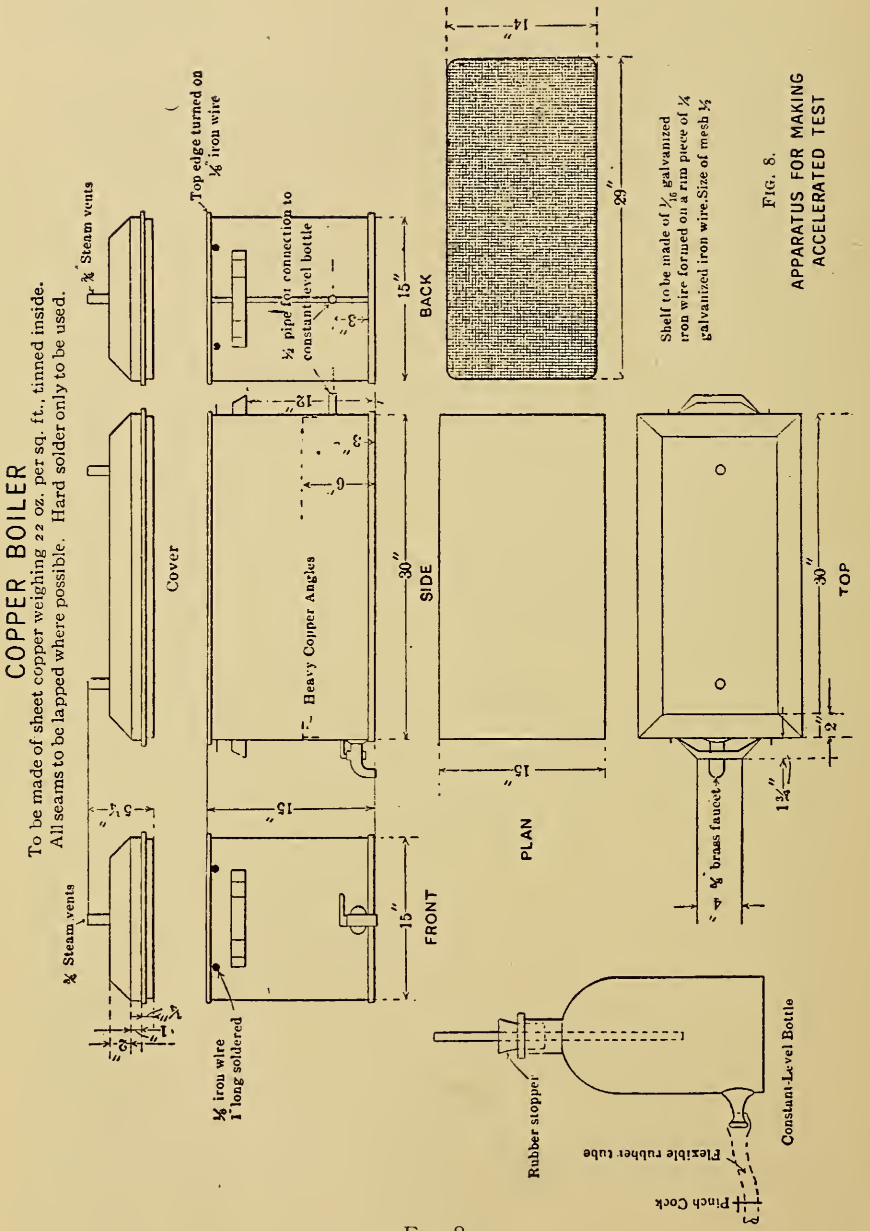
COPPER BOILER
To be made of sheet copper weighing 22 oz. per sq. ft., tinned inside.
All seams to be lapped where possible. Hard solder only to be used.
¾" Steam vents
¾" Steam vents
Cover
Top edge turned on ⅛" iron wire
½ pipe for connection to constant level bottle
Heavy Copper Angles
⅜ iron wire 1" long soldered
5¼"
2"
1"
½"
15"
15"
30"
15"
12"
6"
3"
3"
FRONT
SIDE
BACK
14"
29"
Shelf to be made of 1/16 galvanized iron wire formed on a rim piece of ¼ galvanized iron wire. Size of mesh ½
Fig. 8.
APPARATUS FOR MAKING ACCELERATED TEST
15"
PLAN
30"
TOP
2"
1¾"
⅜" brass faucet
Rubber stopper
Flexible rubber tube
Pinch Cock
Constant-Level Bottle

Fig. 8.

difference between this weight and the weight previously obtained gives the amount of silica.[*]

Alumina and Iron (Al_2O_3 and Fe_2O_3).

The filtrate, about 250 c.c., from the second evaporation for SiO_2, is made alkaline with NH_4OH after adding HCl, if need be, to insure a total of 10 to 15 c.c. strong acid, and boiled to expell excess of NH_3, or until there is but a faint odor of it, and the precipitate iron and aluminum hydrates, after settling, are washed once by decantation and slightly on the filter. Setting aside the filtrate, the precipitate is dissolved in hot dilute HCl, the solution passing into the beaker in which the precipitation was made. The aluminum and iron are then reprecipitated by NH_4OH, boiled and the second precipitate collected and washed on the same filter used in the first instance. The filter paper, with the precipitate, is then placed in a weighed platinum crucible, the paper burned off and the precipitate ignited and finally blasted 5 minutes, with care to prevent reduction, cooled and weighed as $Al_2O_3+Fe_2O_3$.[†]

Iron (Fe_2O_3).

The combined iron and aluminum oxides are fused in a platinum crucible at a very low temperature with about 3 or 4 grammes of $KHSO_4$, or, better, $NaHSO_4$, the melt taken up with so much dilute H_2SO_4 that there shall be no less than 5 grammes absolute acid and enough water to effect solution on heating. The solution is then evaporated and eventually heated till acid fumes come off copiously. After cooling and redissolving in water the small amount of silica is filtered out, weighed and corrected by HFl and H_2SO_4.[‡] The filtrate is reduced by zinc or preferably by hydrogen sulphide, boiling out the excess of the latter afterwards while passing CO_2, through the flask, and titrated with permanganate.[§] The strength of the permanganate solution should not be greater than .0040 g. Fe_2O_3 per c.c.

Lime (CaO).

To the combined filtrate from the $Al_2O_3+Fe_2O_3$ precipitate, a few drops of NH_4OH are added, and the solution brought to boiling. To the boiling solution 20 c.c. of a saturated solution of ammonium oxalate are added, and the boiling continued until the precipitated CaC_2O_4 assumes a well-defined granular form. It is then allowed to stand for 20 minutes, or until the precipitate has settled, and then filtered and washed. The precipitate and filter are placed wet in a platinum crucible, and the paper burned off over a small flame of a Bunsen burner. It is then ignited, redissolved in HCl, and the solution made up to 100 c.c. with water. Ammonia is added in slight excess, and the liquid is boiled. If a small amount of Al_2O_3 separates, this is filtered out, weighed, and the amount added to that found in the first determination, when greater accuracy is desired. The lime is then reprecipitated by ammonium oxalate, allowed to stand until settled, filtered and washed,* weighed as oxide by ignition and blasting in a covered crucible to constant weight, or determined with dilute standard permanganate.†

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[*] For ordinary control in the plant laboratory this correction may, perhaps, be neglected; the double evaporation never.

[†] This precipitate contains TiO_2, P_2O_5, Mn_3O_4.

[‡] This correction of $Al_2O_3Fe_2O_3$ for silica should not be made when the HFl correction of the main silica has been omitted, unless that silica was obtained by only one evaporation and filtration. After two evaporations and filtrations 1 to 2 mg. of SiO are still to be found with the $Al_2O_3Fe_2O_3$.

[§] In this way only is the influence of titanium to be avoided and a correct result obtained for iron.

Magnesia (MgO).

The combined filtrates from the calcium precipitates are acidified with HCl and concentrated on the steam bath to about 150 c.c., 10 c.c. of saturated solution of $Na(NH_4)HPO_4$ are added, and the solution boiled for several minutes. It is then removed from the flame and cooled by placing the beaker in ice water. After cooling, NH_4OH is added drop by drop with constant stirring until the crystalline ammonium-magnesium ortho-phosphate begins to form, and then in moderate excess, the stirring being continued for several minutes. It is then set aside for several hours in a cool atmosphere and filtered. The precipitate is redissolved in hot dilute HCl, the solution made up to about 100 c.c., 1 c.c. of a saturated solution of $Na(NH_4)HPO_4$ added, and ammonia drop by drop, with constant stirring until the precipitate is again formed as described and the ammonia is in moderate excess. It is then allowed to stand for about 2 hours, when it is filtered on a paper or a Gooch crucible, ignited, cooled and weighed as $Mg_2P_2O_7$.

Alkalies (K_2O and Na_2O).

For the determination of the alkalies, the well-known method of Prof. J. Lawrence Smith is to be followed, either with or without the addition of $CaCO_3$ with NH_4Cl.

Anhydrous Sulphuric Acid (SO_3).

One gramme of the substance is dissolved in 15 c.c. of HCl, filtered and residue washed thoroughly.‡

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* The volume of wash-water should not be too large; *vide* Hillebrand.

† The accuracy of this method admits of criticism, but its convenience and rapidity demand its insertion.

‡ Evaporation to dryness is unnecessary, unless gelatinous silica should have separated and should never be performed on a bath heated by gas; *vide* Hillebrand.

The solution is made up to 250 c.c. in a beaker and boiled. To the boiling solution 10 c.c. of a saturated solution of $BaCl_2$ is added slowly drop by drop from a pipette and the boiling continued until the precipitate is well formed, or digestion on the steam bath may be substituted for the boiling. It is then set aside over night, or for a few hours, filtered, ignited and weighed as $BaSO_4$.

Total Sulphur.

One gramme of the material is weighed out in a large platinum crucible and fused with Na_2CO_3 and a little KNO_3 being careful to avoid contamination from sulphur in the gases from source of heat. This may be done by fitting the crucible in a hole in an asbestos board. The melt is treated in the crucible with boiling water and the liquid poured into a tall narrow beaker and more hot water added until the mass is disintegrated. The solution is then filtered. The filtrate contained in a No. 4 beaker is to be acidulated with HCl and made up to 250 c.c. with distilled water, boiled, the sulphur precipitated as $BaSO_4$ and allowed to stand over night or for a few hours.

Loss on Ignition.

Half a gramme of cement is to be weighed out in a platinum crucible, placed in a hole in an asbestos board so that about three-fifths of the crucible projects below, and blasted 15 minutes, preferably with an inclined flame. The loss by weight, which is checked by a second blasting of 5 minutes, is the loss on ignition.

May, 1903: Recent investigations have shown that large errors in results are often due to the use of impure distilled water and reagents. The analyst should, therefore, test his distilled water by evaporation and his reagents by appropriate tests before proceeding with his work.

[5]SPECIFICATIONS FOR STONE MASONRY.

GENERAL.

Standard Specifications.

1. The requirements for cement and concrete shall be those adopted by the American Railway Engineering Association.

Engineer Defined.

2. Where the term "Engineer" is used in these specifications, it refers to the Engineer actually in charge of the work.

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[5] Adopted, Vol. 7, 1906; pp. 581-587, 602-604, 606-622; Vol. 8, p. 634; Vol. 9, 1908, pp. 650-655, 659; Vol. 12, Part 1, 1911, pp. 478, 579.

GENERAL REQUIREMENTS.

Stone.

3. Stone shall be of the kinds designated and shall be hard and durable, of approved quality and shape, free from seams, or other imperfections. Unseasoned stone shall not be used where liable to injury by frost.

Dressing.

4. Dressing shall be the best of the kind specified.

5. Beds and joints or builds shall be square with each other, and dressed true and out of wind. Hollow beds shall not be permitted.

6. Stone shall be dressed for laying on the natural bed. In all cases the bed shall not be less than the rise.

7. Marginal drafts shall be neat and accurate.

8. Pitching shall be done to true lines and exact batter.

Mortar.

9. Mortar shall be mixed in a suitable box, or in a machine mixer, preferably of the batch type, and shall be kept free from foreign matter. The size of the batch and the proportions and the consistency shall be as directed by the Engineer. When mixed by hand the sand and cement shall be mixed dry, the requisite amount of water then added and the mixing continued until the cement is uniformly distributed and the mass is uniform in color and homogeneous.

Laying.

10. The arrangement of courses and bond shall be as indicated on the drawings, or as directed by the Engineer. Stone shall be laid to exact lines and levels, to give the required bond and thickness of mortar in beds and joints.

11. Stone shall be cleansed and dampened before laying.

12. Stone shall be well bonded, laid on its natural bed and solidly settled into place in a full bed of mortar.

13. Stone shall not be dropped or slid over the wall, but shall be placed without jarring stone already laid.

14. Heavy hammering shall not be allowed on the wall after a course is laid.

15. Stone becoming loose after the mortar is set shall be relaid with fresh mortar.

16. Stone shall not be laid in freezing weather, unless directed by the Engineer. If laid, it shall be freed from ice, snow or frost by warming. The sand and water used in the mortar shall be heated.

17. With precaution, a brine may be substituted for the heating of the mortar. The brine shall consist of one pound of salt to eighteen gallons of water, when the temperature is 32 degrees Fahrenheit; for every degree of temperature below 32 degrees Fahrenheit, one ounce of salt shall be added.

Pointing.

18. Before the mortar has set in beds and joints, it shall be removed to a depth of not less than one inch. Pointing shall not be done until the wall is complete and mortar set; nor when frost is in the stone.

19. Mortar for pointing shall consist of equal parts of sand, sieved to meet the requirements, and Portland cement. In pointing, the joints shall be wet, and filled with mortar, pounded in with a "set-in" or calking tool and finished with a beading tool the width of a joint, used with a straight-edge.

BRIDGE AND RETAINING WALL MASONRY, ASHLAR STONE.

Bridge and Retaining Wall Masonry, Ashlar Stone.

20. The stone shall be large and well proportioned. Courses shall not be less than 14 inches or more than 30 inches thick, thickness of courses to diminish regularly from bottom to top.

Dressing.

21. Beds and joints or builds of face stone shall be fine-pointed, so that the mortar layer should not be more than ½-inch thick when the stone is laid.

22. Joints in face stone shall be full to the square for a depth equal to at least one-half the height of the course, but in no case less than 12 inches.

Face or Surface.

23. Exposed surfaces of the face stone shall be rock-faced, with edges pitched to the true lines and exact batter. The face shall not project more than 3 inches beyond the pitch line.

24. Chisel drafts 1½ inches wide shall be cut at exterior corners.

25. Holes for stone hooks shall not be permitted to show in exposed surfaces. Stone shall be handled with clamps, keys, lewis or dowels.

Stretchers.

26. Stretchers shall not be less than 4 feet long with at least one and a quarter times as much bed as thickness of course.

Headers.

27 Headers shall not be less than 4 feet long; shall occupy one-fifth of face of wall; shall not be less than 18 inches wide in face; and, where the course is more than 18 inches high, width of face shall not be less than height of course.

28. Headers shall hold in heart of wall the same size shown in face, so arranged that a header in a superior course shall not be laid over a joint, and a joint shall not occur over a header; the same disposition shall occur in back of wall.

29. Headers in face and back of wall shall interlock when thickness of wall will admit.

30. Where the wall is 3 feet thick or less, the face stone shall pass entirely through. Backing shall not be permitted.

Backing.

*31-a. Backing shall be large, well-shaped stone, roughly bedded and jointed; bed joints shall not exceed 1 inch. At least one-half of the backing stone shall be of same size and character as the face stone and with parallel ends. The vertical joints in back of wall shall not exceed 2 inches. The interior vertical joints shall not exceed 6 inches.

Voids shall be thoroughly filled with *concrete.*
spalls, fully bedded in cement mortar.

*31-b. Backing shall be of *concrete.*
headers and stretchers, as specified in paragraphs 26 and 27, and heart of wall filled with concrete.

32. Where the wall will not admit of such arrangement, stone not less than four (4) ft. long shall be placed transversely in heart of wall to bond the opposite sides.

33. Where stone is backed with two courses, neither course shall be less than eight (8) in. thick.

Bond.

34. Bond of stone in face, back and heart of wall shall not be less than 12 inches. Backing shall be laid to break joints with the face stone and with one another.

Coping.

35. Coping stone shall be full size throughout, of dimensions indicated on the drawings.

36. Beds, joints and top shall be fine-pointed.

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* Paragraphs 31-a and 31-b are so arranged that either may be eliminated according to requirements. Optional clauses printed in italics.

37. Location of joints shall be determined by the position of the bed plates, as indicated on the drawings.

Locks.

38. Where required, coping stone, stone in the wings of abutments, and stone on piers, shall be secured together with iron cramps or dowels, to the position indicated on the drawings.

BRIDGE AND RETAINING WALL MASONRY—RUBBLE STONE.

39. The stone shall be roughly squared, and laid in irregular courses. Beds shall be parallel, roughly dressed, and the stone laid horizontal to the wall. Face joints shall not be more than 1 inch thick. Bottom stone shall be large, selected flat stone.

40. The wall shall be compactly laid, having at least one-fifth the surface of back and face headers arranged to interlock, having all voids in the heart of the wall thoroughly filled with
concrete.
suitable stones and spalls, fully bedded in cement mortar.

ARCH MASONRY, ASHLAR STONE.

Arch Masonry, Ashlar Stone.

41. Voussoirs shall be full size throughout and dressed true to templet, and shall have bond not less than thickness of stone.

Dressing.

42. Joints of voussoirs and intrados shall be fine-pointed. Mortar joints shall not exceed ⅜-inch.

Face or Surface.

43. Exposed surface of the ring stone shall be
smooth.
rock faced, with a marginal draft.

44. Number of courses and depth of voussoirs shall be indicated on the drawings.

45. Voussoirs shall be placed in the order indicated on the drawings.

Backing.

46. Backing shall consist of
concrete.
large stone, shaped to fit the arch bonded to the spandrel and laid in full bed of mortar.

47. Where waterproofing is required, a thin coat of mortar or grout shall be applied evenly for a finishing coat, upon which shall be placed a covering of approved waterproofing material. (See page 292.)

48. Centers shall not be struck until directed by the Engineer.

Bench Walls, Piers, Spandrels, etc.

49. Bench walls, piers, spandrels, parapets, wing walls and copings shall be built under the specifications for Bridge and Retaining Wall Masonry, Ashlar Stone.

ARCH MASONRY—RUBBLE STONE.

Arch Masonry, Rubble Stone. Dressing.

50. Voussoirs shall be full size throughout, and shall have bond not less than thickness of voussoirs.

51. Beds shall be roughly dressed to bring them to radial planes.

52. Mortar joints shall not exceed 1 inch.

Face or Surface.

53. Exposed surfaces of ring stone shall be rock-faced, and edges pitched to true lines.

54. Voussoirs shall be placed in the order indicated on the drawings.

Backing.

55. Backing shall consist of *concrete.*
large stone, shaped to fit the arch, bonded to the spandrel, and laid in full bed of mortar.

56. Where waterproofing is required, a thin coat of mortar or grout shall be applied evenly for a finishing coat, upon which shall be placed a covering of approved waterproofing material. (For information on Waterproofing Masonry, see page 292.)

57. Centers shall not be struck until directed by the Engineer.

Bench Walls, Piers, Spandrels, etc.

58. Bench walls, piers, spandrels, parapets, wing walls and copings shall be built under the specifications for Bridge and Retaining Wall Masonry, Rubble Stone.

CULVERT MASONRY.

Culvert Masonry.

59. Culvert Masonry shall be laid in cement mortar. Character of stone and quality of work shall be the same as specified for Bridge and Retaining Wall Masonry, Rubble Stone.

Side Walls.

60. One-half the top stone of the side walls shall extend entirely across the wall.

Cover Stones.

61. Covering stone shall be sound and strong, at least 12 inches thick, or as indicated on the drawings. They shall be roughly dressed to make close joints with each other, and lap their entire width at least 12 inches over the side walls. They shall be doubled under high embankments, as indicated on the drawings.

End Walls, Coping.

62. End walls shall be covered with suitable coping, as indicated on the drawings.

DRY MASONRY.

Dry Masonry.

63. Dry Masonry shall include dry retaining walls and slope walls.

Retaining Walls.

64. Retaining Walls and Dry Masonry shall include all walls in which rubble stone laid without mortar is used for retaining embankments or for similar purposes.

Dressing.

65. Flat stone at least twice as wide as thick shall be used. Beds and joints shall be roughly dressed square to each other and to face of stone.

66. Joints shall not exceed ¾-inch.

Disposition of Stone.

67. Stone of different sizes shall be evenly distributed over entire face of wall, generally keeping the larger stone in lower part of wall.

68. The work shall be well bonded, and shall present a reasonably true and smooth surface, free from holes or projections.

Slope Walls.

69. Slope walls shall be built of such thickness and slope as directed by the Engineer. Stone used in this construction must reach entirely through the wall. Stone shall be placed at right angles to the slopes. The wall shall be built simultaneously with the embankment which it is to protect.

[6] SPECIFICATIONS FOR PLAIN AND REINFORCED CONCRETE AND STEEL REINFORCEMENT.

CONCRETE MATERIALS.

Cement.

1. The cement shall be Portland and shall meet the requirements of the standard specifications.

Fine Aggregates.

2. Fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse, and passing when dry a screen

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[6] Adopted, Vol. 11, 1910, pp. 962-967, 1019, 1020.

having ¼-inch diameter holes; it shall preferably be of hard siliceous material, clean, free from dust, soft particles, vegetable loam or other deleterious matter, and not more than 6 per cent. shall pass a sieve having 100 meshes per linear inch.

3. The fine aggregate shall be of such quality that mortar composed of one part Portland cement and three parts fine aggregate by weight when made into briquettes shall show a tensile strength at least equal to the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand†.

Coarse Aggregates.

4. Coarse aggregate shall consist of material such as crushed stone or gravel, which is retained on a screen having ¼-inch diameter holes and having gradation of sizes from the smallest to the largest particles; it shall be clean, hard, durable and free from all deleterious matter. Aggregates containing dust, soft or elongated particles shall not be used.

Water.

5. The water used in mixing concrete shall be free from oil, acid, and injurious amounts of alkalies or vegetable matter.

STEEL REINFORCEMENT.

Manufacture.

6. Steel shall be made by the open-hearth process. Rerolled material will not be accepted.

7. Plates and shapes used for reinforcement shall be of structural steel only. Bars and wire may be of structural steel or high carbon steel.

Schedule of Requirements.

8. The chemical and physical properties shall conform to the following limits:

Elements Considered.		Structural Steel.	High Carbon Steel.
Phosphorus, max....	Basic...............	0.04 per cent.	0.04 per cent.
	Acid...............	0.06 per cent.	0.06 per cent.
Sulphur, maximum........................		0.05 per cent.	0.05 per cent.
Ultimate tensile strength. Pounds per square inch....................		Desired 60,000	Desired 88,000
Elong., min. % in 8", Fig. 1..............		1,500,000* Ult. tensile str'gth	1,000,000 Ult. tensile str'gth
Character of Fracture......................		Silky	Silky or finely granular.
Cold Bends without Fracture..............		180° flat	180° $d=4t$‡

*See paragraph 15. ‡"$d=4t$" signifies "around a pin whose diameter is four times the thickness of the specimen."

† This sand may be obtained from the Ottawa Silica Company at a cost of 2 cents per pound f. o. b. cars, Ottawa, Ill.

Yield Point.

9. The yield point for bars and wire, as indicated by the drop of the beam, shall be not less than 60 per cent. of the ultimate tensile strength.

Allowable Variations.

10. If the ultimate strength varies more than 4000 lbs. for structural steel or 6000 lbs. for high carbon steel, a retest shall be made on the same gage, which, to be acceptable, shall be within 5000 lbs. for structural steel, or 8000 lbs. for high carbon steel, of the desired ultimate.

Chemical Analyses.

11. Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the Engineer or his inspector. Check analysis shall be made from finished material, if called for by the Railroad Company, in which case an excess of 25 per cent. above the required limits will be allowed.

Form of Specimens.

12. Plates, Shapes and Bars: Specimens for tensile and bending tests for plates and shapes shall be made by cutting coupons from the finished product, which shall have both faces rolled and both edges milled to the form shown by Fig. 1; or with edges parallel; or they may be turned to a diameter of ¾-inch with enlarged ends.

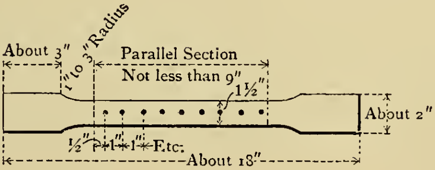

FIG. 1.

13. Bars shall be tested in their finished form.

Number of Tests.

14. At least one tensile and one bending test shall be made from each melt of steel as rolled. In case steel differing ⅜-inch and more in thickness is rolled from one melt, a test shall be made from the thickest and thinnest material rolled.

Modifications in Elongation.

15. For material less than $\frac{5}{16}$-inch and more than ¾-inch in thickness the following modifications will be allowed in the requirements for elongation:

(a) For each $\frac{1}{16}$-inch in thickness below $\frac{5}{16}$-inch a deduction of 2½ will be allowed from the specified percentage.

(b) For each ⅛-inch in thickness above ¾-inch, a deduction of 1 will be allowed from the specified percentage.

Bending Tests.

16. Bending tests may be made by pressure or by blows. Shapes and bars less than one inch thick shall bend as called for in paragraph 8.

Thick Material.

17. Test specimens one inch thick and over shall bend cold 180 degrees around a pin, the diameter of which, for structural steel, is twice the thickness of the specimen, and for high-carbon steel, is six times the thickness of the specimen, without fracture on the outside of the bend.

Finish.

18. Finished material shall be free from injurious seams, flaws, cracks, defective edges or other defects. It shall have a smooth, uniform and workmanlike finish.

Stamping.

19. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it, except that bar steel and other small parts may be bundled with the above marks on an attached metal tag.

Defective Material.

20. Material which, subsequent to the above tests at the mills, and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected and shall be replaced by the manufacturer at his own cost.

21. Reinforcing steel shall be free from excessive rust, loose scale, or other coatings of any character, which would reduce or destroy the bond.

WORKMANSHIP.

Unit of Measure.

22. The unit of measure shall be the cubic foot. A bag containing not less than 94 lbs. of cement shall be assumed as one cubic foot of cement. Fine and coarse aggregates shall be measured separately as loosely thrown into the measuring receptacle.

Proportions.

23. The proportions of materials for the different classes of concrete shall be as follows:

Class.	Use.	Cement.	Aggregates.	
			Fine.	Coarse.

Note:—This blank to be filled for each contract.

Relation of Fine and Coarse Aggregates.

24. The proportion of cement used to the total aggregates shall be as called for in the above table, the relative proportions of fine aggregates to coarse aggregates shall always be such as to give the maximum density, this proportion to be adjusted during the progress of the work so as to secure the required result.

Mixing.

25. The ingredients of concrete shall be thoroughly mixed to the desired consistency, and the mixing shall continue until the cement is uniformly distributed and the mass is uniform in color and homogeneous.

Measuring Proportions.

26. The various ingredients, including the water, shall be measured separately, and the methods of measurement shall be such as to invariably secure the proper proportions.

Machine Mixing.

27. A machine mixer, preferably of the batch type, shall be used, wherever the volume of the work will justify the expense of installing

the plant. The requirements demanded are that the product delivered shall be of the specified proportions and consistency and thoroughly mixed.

Hand Mixing.

28. When it is necessary to mix by hand, the mixing shall be on a watertight platform of sufficient size to accommodate men and materials for the progressive and rapid mixing of at least two batches of concrete at the same time. Batches shall not exceed one-half cubic yard each. The mixing shall be done as follows: the fine aggregates shall be spread evenly upon the platform, then the cement upon the fine aggregates, and these mixed thoroughly until of an even color. The water necessary to mix a thin mortar shall then be added and the mortar spread again. The coarse aggregates, which, if dry, shall first be thoroughly wetted, shall then be added to the mortar. The mass shall then be turned with shovels or hoes until thoroughly mixed and all the aggregates covered with mortar. Or, at the option of the Engineer, the coarse aggregates may be added before, instead of after, adding the water.

Consistency.

29. The materials shall be mixed wet enough to produce a concrete of such consistency that it will flow into the forms and about the metal reinforcement, and which, on the other hand, can be conveyed from the place of mixing to the forms without separation of the coarse aggregates from the mortar.

Retempering.

30. Retempering mortar or concrete, i. e., remixing with water after it has partially set, will not be permitted.

Placing of Concrete.

31. Concrete after the completion of the mixing shall be handled rapidly to the place of final deposit, and under no circumstances shall concrete be used that has partially set before final placing.

32. The concrete shall be deposited in such a manner as will prevent the separation of the ingredients and permit the most thorough compacting. It shall be compacted by working with a straight shovel or slicing tool kept moving up and down until all the ingredients have settled in their proper place and the surplus water is forced to the surface. In general, except in arch work, all concrete must be deposited in horizontal layers of uniform thickness throughout.

33. In depositing concrete under water, special care shall be exercised to prevent the cement from floating away and to prevent the forma-

tion of laitance. (For information on depositing concrete under water, see page 293.)

34. Before depositing concrete the forms shall be thoroughly wetted (except in freezing weather) or oiled, and the space to be occupied by the concrete cleared of débris.

35. Before placing new concrete on or against concrete which has set, the surface of the latter shall be roughened, thoroughly cleansed of foreign material and laitance, drenched and slushed with a mortar consisting of one part Portland cement and not more than two parts fine aggregate.

36. The faces of concrete exposed to premature drying shall be kept wet for a period of at least three days.

Freezing Weather.

37. Concrete shall not be mixed or deposited at a temperature below 40 degrees Fahrenheit, unless the water and aggregates are heated to a temperature of at least 60 degrees Fahrenheit, and means provided to insure that the concrete will not freeze during the period of initial set.

Rubble Concrete.

38. Where the concrete is to be deposited in massive work, clean, large stones, evenly distributed, thoroughly bedded and entirely surrounded by concrete, may be used, at the option of the Engineer.

Forms.

39. Forms shall be substantial and unyielding and built so that the concrete shall conform to the designed dimensions and contours, and so constructed as to prevent the leakage of mortar. Temporary openings shall be provided at the base of all column and wall forms to facilitate cleaning and inspection directly before concreting.

40. The forms shall not be removed until authorized by the Engineer.

41. For all important work, the lumber used for face work shall be dressed to a uniform thickness and width; shall be sound and free from loose knots and secured to the studding or uprights in horizontal lines.

42. For backings and other rough work undressed lumber may be used.

43. Where corners of the masonry and other projections liable to injury occur, suitable moldings shall be placed in the angles of the forms to round or bevel them off.

44. Lumber once used in forms shall be cleaned before being used again.

45. Reinforcement shall be cleaned of all rust scales and carefully placed in accordance with the plans. Adequate means shall be provided to hold it in its proper position until the concrete has been deposited. After the reinforcement is in place, and before it is embedded in concrete, the reinforcement shall be inspected and approved by the Engineer.

DETAILS OF CONSTRUCTION.

Splicing Reinforcement.

46. Wherever it is necessary to splice the reinforcement otherwise than as shown on the plans, the character of the splice shall be decided by the Engineer on the basis of the safe bond stress and the stress in the reinforcements at the point of splice. Splices shall not be made at points of maximum stress.

Joints in Concrete.

47. Concrete structures, wherever possible, shall be cast at one operation, but when this is not possible, the resulting joint shall be formed where it will least impair the strength and appearance of the structure.

48. Girders and slabs shall be cast integrally and shall not be constructed over freshly formed walls or columns without permitting a period of at least four hours to elapse to provide for settlement or shrinkage in the supports. Before resuming work, the tops of such walls or columns shall be cleaned of foreign matter and laitance. The following exceptions to the above rule may be made:

(a) Where structural steel columns are used, the concrete encasing the same may be poured at the same time as the girders and slab above.

(b) Where columns have flaring heads, the column heads shall be poured at the same time as the slab and in this case the column shaft may be poured at the same time as the slab and column head.

49. A triangular-shaped groove shall be formed at the surface of the concrete at vertical joints in walls and abutments.

Surface Finish.

50. Except where a special surface finish is required, a spade or special tool shall always be worked between the concrete and the form to force back the coarse aggregates and produce a mortar face.

Top Surfaces.

51. Top surfaces shall generally be "struck" with a straight edge or "floated" after the coarse aggregates have been forced below the surface.

Sidewalk Finish.

52. Where a "sidewalk finish" is called for on the plans, it shall be made by spreading a layer of 1:2 mortar at least ¾-inch thick, troweling the same to a smooth surface. This finishing coat shall be put on before the concrete has taken its initial set.

[7] DESIGNS OF REINFORCED CONCRETE STRUCTURES.

Materials.

(1) The materials and workmanship for reinforced concrete should meet the requirements of the "Specifications for Plain and Reinforced Concrete."

The concrete recommended for general use is a mixture of one part of cement, two parts of fine and four parts of coarse aggregates. A richer mixture will be found advantageous for special conditions.

Dead Load.

(2) The dead load is to include the estimated weight of the structure and all other fixed loads and forces acting upon the structure.

Live Load.

(3) The live load is to include all variable and moving loads or forces acting upon the structure in any direction.

Impact. Span Lengths.

(4) As the working stresses herein recommended are for static loads, the dynamic effect of moving loads is to be added to the live load stresses.*

(5) For calculating stresses the span length for bending moment for beams and slabs is to be taken as the distance from center to center of the supports, but not to exceed the clear span plus the depth of beam or slab.

Internal Stresses.

(6) The internal stresses are to be calculated upon the basis of the following assumptions:

(a) A plane section before bending remains plane after bending.

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[7] Adopted, Vol. 11, 1910, pp. 967-969, 1019, 1020.

* The following formula is not recommended by the Committee, but is merely given as an illustration:

$$\text{Impact} = \frac{L}{L+D} L$$

L=Live load stress. D=Dead load stress.

(b) The distribution of compressive stresses in members subject to bending is rectilinear.

(c) The ratio of the moduli of elasticity of steel and 1:2:4 concrete is assumed 15.

(d) The tensile stresses in the concrete are neglected in calculating the moment of resistance of beams.

(e) The initial stress in the reinforcement due to contraction or expansion in the concrete is neglected.

(f) The depth of a beam is the distance from the compressive face to the centroid of the tension reinforcement.

(g) The effective depth of a beam at any section is the distance from the centroid of the compressive stresses to the centroid of the tension reinforcement.

(h) The maximum shearing unit stress in beams is the total shear at the section divided by the product of the width of the section and the effective depth at the section considered. This maximum shearing unit stress is to be used in place of the diagonal tension stress in calculations for web stresses.

(i) The bond unit stress is equal to the vertical shear divided by the product of the total perimeter of the reinforcement in the tension side of the beam and the effective depth at the section considered.

(k) For columns in fireproof construction and in hooped columns the outside concrete to a depth of 1½ inches is to be considered as a protective covering and is not to be included in the effective section.

Web Stresses.

*(7) "When the maximum shearing stresses exceed the value allowed for the concrete alone, web reinforcement should be provided to aid in carrying the diagonal tension stresses. This web reinforcement may consist of bent bars, or inclined or vertical members, attached to or looped about the horizontal reinforcement. Where inclined members are used, the connection to the horizontal reinforcement should be such as to insure against slip.

"In the calculation of web reinforcement when the concrete alone is insufficient to take the diagonal tension the concrete may be counted upon as carrying one-third of the shear. The remainder is to be provided for by means of metal reinforcement consisting of bent bars or stirrups, but preferably both. The requisite amount of such reinforcement may be estimated on the assumption that the entire shear on a section, less the amount assumed to be carried by the concrete, is carried by the reinforcement in a length of beam equal to its depth."

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* The recommendations regarding web stresses are quoted from a report of the Joint Committee on Concrete and Reinforced Concrete.

Shrinkage and Temperature Reinforcement.

(8) Reinforcement for shrinkage or temperature stresses, in amount generally not less than one-third of 1 per cent., and of a form which will develop a high bond resistance, should be placed and be well distributed near the exposed surface of the concrete.

Working Stresses.

(9) The following recommended working stresses, in pounds per square inch of section, are for use in concrete of such quality as to be capable of developing an average compressive strength of at least 2000 lbs. per square inch when tested in cylinders 8 inches in diameter and 16 inches long and 28 days old, under laboratory conditions of manufacture and storage, the mixture being of the same consistency as is used in the field:

Structural steel in tension	14,000
High carbon steel in tension	16,000
Steel in compression, 15 times the compressive stress in the surrounding concrete.	
Concrete in bearing where the surface is at least twice the loaded area	700
Concrete in direct compression, without reinforcement on lengths not exceeding six times the least width	450
Concrete in direct compression with not less than 1 per cent. nor over 4 per cent. longitudinal reinforcement on lengths not exceeding twelve times the least width, provided, the longitudinal reinforcement is held in position by horizontal hoops, or a continuous spiral spaced not more than 6 inches apart	450
Concrete in compression, on extreme fiber in cross bending	750
Concrete in shear, uncombined with tension or compression in the concrete	120
Concrete in shear, where the shearing stress is used as the measure of web stress	40
Note.—The limit of shearing stresses in the concrete, even when thoroughly reinforced for shear and diagonal tension, should not exceed	120
Bond for plain and twisted bars	80
Bond for drawn wire	40
Bond for deformed bars, depending upon form	80-100

[8] MONOLITHIC CONSTRUCTION.

DEFINITIONS.

Monolith of Concrete.—A single mass of concrete made without joints by a continuous operation of construction.

Monolithic Concrete Construction.—Monolithic concrete construction is the building of a single mass of concrete without joints by a continuous operation.

PRINCIPLES OF PRACTICE.

These conclusions are based upon the supposition that the structure is well designed and that the foundation is good:

(1) Monolithic concrete construction may be used without danger of cracking for abutments of any length that the working conditions will permit, provided the length does not exceed about three times the height.

(2) Where abutments with wing walls are not of monolithic construction, joints should be provided at the intersections of the wing walls and the body of the abutments.

(3) Reinforced concrete abutments may be built in units of any length that economic conditions will permit.

(4) Monolithic concrete construction may be used for arches where the conditions will permit, otherwise the arch ring should be constructed with radial joints.

[9] WATERPROOFING OF MASONRY.

(1) Watertight concrete may be obtained by proper design. Reinforcing the concrete against cracks due to expansion and contraction, using the proper proportion of cement and graded aggregates to secure the filling of voids and employing proper workmanship and close supervision.

(2) Membrane waterproofing, of either asphalt or pure coal-tar pitch in connection with felts and burlaps, with proper number of layers,

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[8] Adopted, Vol. 12, Part 1, 1911, pp. 516, 580.

[9] Adopted, Vol. 15, 1914, pp. 536, 1061.

good materials and workmanship and good working conditions, is recommended as good practice for waterproofing masonry, concrete and bridge floors.

(3) Permanent and direct drainage of bridge floors is essential to secure good results in waterproofing.

(4) Integral methods of waterproofing concrete have given some good results. Special care is required to properly proportion the concrete, mix thoroughly and deposit properly so as to have the void-filling compounds do the required duty; if this is neglected, the value of the compounds is lost and their waterproofing effect destroyed. Careful tests should be made to ascertain the proper proportions and effectiveness of such compounds.

Integral compounds should be used with caution, ascertaining their chemical action on the concrete as well as their effect on its strength. As a general rule, integral compounds are not recommended, since the same results as to watertightness can be obtained by adding a small percentage of cement and properly grading the aggregate.

(5) Surface coating, such as cement mortar, asphalt or bituminous mastic, if properly applied to masonry reinforced against cracks produced by settlement, expansion and contraction, may be successfully used for waterproofing arches, abutments, retaining walls, reservoirs, and similar structures; for important work under high pressure of water these cannot be recommended for all conditions.

(6) Surface brush coatings, such as oil paints and varnishes, are not considered reliable or lasting for waterproofing of masonry.

[10] METHODS OF DEPOSITING CONCRETE UNDER WATER.

(1) Concrete may be deposited successfully under water, if so handled as to prevent the washing of the cement from the mixture.

(2) Cofferdams should be sufficiently tight to prevent current through the pit, and the water in the pit should be quiet.

(3) The concrete should be deposited in place either by means of a drop-bottom bucket or a tremie, and should not be allowed to fall through the water.

(4) Where a bucket is used, it should be carefully lowered to the bottom and raised to the surface, so as to cause as little disturbance as possible to the water.

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[10] Adopted, Vol. 13, 1912, pp. 488, 994.

(5) Where a tremie is used, it should be kept filled with concrete up to the top of the water level, and the discharge end should be kept buried in the freshly deposited mass to prevent emptying, and raised a few inches at a time as the filling progresses.

(6) The surface of the concrete must be kept as nearly level as possible to avoid the formation of pockets which will retain laitance and sediment.

(7) Where concrete is not deposited continuously, all sediment should be removed from the surface of the concrete, by pumping or otherwise, before depositing fresh concrete.

(8) The concrete should be a 1:2:4 mixture and of "quaking" consistency.

(9) Freshly deposited concrete should not be disturbed.

(10) In open water, where the flow of water through the pit cannot be prevented, concrete should be deposited in cloth sacks.

[11] DISINTEGRATION OF CONCRETE AND CORROSION OF REINFORCING METAL.

(1) Concrete to be exposed to the action of sea water, or alkali waters, or gases containing sulphur, or in which reinforcing metal is embedded should be dense, rich in Portland cement and allowed to harden under favorable conditions before such exposure.

(2) Concrete to be in contact with alkali waters should be made with aggregates inert to the alkalies in the water.

(3) Cinders should not be used for concrete in which reinforcing metal is embedded.

(4) Reinforcing metal should not be painted, but should be thoroughly covered and protected with concrete when in place.

[12] METHOD OF REPAIRING DEFECTIVE OR WORN SURFACES OF CONCRETE.

(1) In all cases the surface to be repaired must first be thoroughly cleaned of all loose material, laitance and dust and the clean, rough, sound concrete exposed to receive the patch. Probably the best method of cleaning is by means of a steam jet.

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[11] Adopted, Vol. 15, 1914, pp. 568, 1062.

[12] Adopted, Vol. 13, 1912, pp. 476, 991-992.

(2) After cleaning, the surface to be repaired must be thoroughly saturated with water, not simply moistened, but so thoroughly drenched that the old concrete will not absorb water from the new mortar or concrete used in patching. If possible, the surface should be kept covered with water for several hours.

(3) If the repair or patch is to be made on a vertical or sloping surface and is not to be more than 1½ in. thick, the surface of the old concrete, while it is still wet, should be spattered or splashed with a cement grout, following this immediately with a fairly stiff plaster coat of mortar made of the same proportions of cement and sand as was used in the original concrete, but never richer than 1 cement to 2½ sand. This plaster coat should not be thicker than ½-in. and each coat should be forced into the surface, but not dragged with a trowel. The surface of each coat, except the final coat, should be "scratched" to give a bond for the next coat. This plastering should preferably begin at the top and progress downward, and only enough time be allowed to permit each coat to receive its initial set before the next coat is applied. The final coat should be finished with a wooden float and only enough water used to properly finish the surface. This patch should be kept damp and protected from sun or frost till fully set up.

(4) If the repair or patch or "finish coat" is to be made on a horizontal or nearly horizontal surface, the surface of the old concrete should be slushed and broomed with a thin cement grout, following this immediately with a *wet* mortar made of 1 part cement and 2½ parts sand or granite screenings and of the full thickness required (not less than ½-in. thick, however). When this mortar begins to take its initial set, it should be floated or troweled to such a finish as may be desired.

(5) If the repair or patch is to be made on a vertical or sloping face and is to be more than 1½ in. thick, it will be advisable to embed dowels into the old concrete, as deeply as the thickness of the proposed patch, and spaced sufficiently close together to firmly anchor the patch to the old concrete. The dowels must be wedged into the old concrete and it will be advisable to fasten wires, metal fabrics or bars to the dowels in the case of extensive patching, as an additional safeguard. The patching may then be done with mortar without forms, or with wet concrete supported by forms, depending upon the thickness and the extent of the patch.

(6) If the repair or patch is to be made on a horizontal or nearly horizontal face and of considerable thickness, dowels may be used, or

the concrete may simply be reinforced by fabric or bars without using dowels—treating the patch as a block of masonry.

(7) Care must be taken not to have thin edges on patches. To avoid this, it may be necessary to cut out sound concrete around a place to be patched, so as to give deep edges to the patch. If possible, the edges should be undercut.

COMMITTEE IX.

SIGNS, FENCES AND CROSSINGS.

[1] DEFINITIONS.

FENCES.

Fence.—A barrier that serves to guard against unrestricted ingress or egress, generally a line of posts with rails or wire, or rails and vertical boards or pickets.

Post.—A piece of wood, metal or other material, set upright and used to support the longitudinal members of a fence.

End Post.—A post at the end of a line or section of fence.

Corner Post.—A post located at the intersection of two lines or sections of fence.

Anchor Post.—A post located between end or corner posts and used as an anchor for stretching wire.

Intermediate or Line Post.—A post placed between end or corner posts.

Rail.—Any longitudinal member of a fence other than wire.

Cleat.—A piece of wood, metal or other material, fastened transversely to the side of a post below the ground to give it greater stability.

Brace.—A piece of wood, metal or other material, in compression, placed diagonally between adjacent posts.

Tie.—A piece of wood, metal or other material, in tension, between adjacent posts.

Panel.—A section of fence between two adjacent posts.

Brace Panel.—A panel in which a brace or tie, or both, are introduced.

Stay.—A piece of wood, metal or other material, used to stiffen the fence and to maintain the spacing of the longitudinal wires.

Staple.—A metal device in the shape of a letter "U" with sharpened ends for fastening the longitudinal wires of the fence to the posts.

Gate.—A movable barrier consisting of a structure of wood, metal or other material, for closing a passageway or an opening in a fence.

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[1] Adopted, Vol. 5, 1904, pp. 381, 382, 386, 390, 446-451, 458, 459; Vol. 16, 1905, pp. 781, 782; Vol. 7, 1906, pp. 458, 479; Vol. 10, Part 1, 1909, pp. 885, 915-917; Vol. 11, Part 2, 1910, pp. 1230, 1231, 1246; Vol. 16, 1915, pp. 435, 436, 1039-1041.

Gate Frame.—The sustaining part of a gate, fitted and framed together, to which the other members are attached.

Gate Brace.—A piece of wood, metal or other material, in compression, placed diagonally and used to stiffen the frame of a gate.

Gate Tie.—A piece of wood, metal or other material, in tension, placed diagonally and used to stiffen the frame of a gate.

Gate Post.—A post on which a gate is carried or to which it is latched.

Snow Fence.—A structure erected for the purpose of forming artificial eddies on the windward side of a cut at sufficient distance away to cause snow to deposit between the snow fence and the cut.

SURFACE STOCK-GUARDS.

Stock-Guard.—A barrier of wood, metal or other material placed between and alongside of track rails to prevent the passage of live stock on or along the railroad track or tracks.

Slat.—A strip of wood, metal or other material used in making up a surface stock-guard.

Filler.—A piece of wood, metal or other material placed between the slats to space and stiffen them.

Apron.—A flared panel of fence set parallel with the track and along outside edge of a stock-guard.

Wing Fence.—A fence connecting the apron of the stock-guard with the right-of-way or line fence.

[3] SPECIFICATIONS FOR STANDARD RIGHT-OF-WAY FENCES.

Classes.

1. Standard right-of-way fences shall be divided into four classes, the height to conform to statutory requirements, generally about 4 feet 6 inches above the ground.

Class A Fence.

2. A Class A fence shall consist of nine longitudinal smooth galvanized steel wires; the top and bottom wires shall be No. 7 gage; the intermediate and stay wires shall be No. 9 gage.

The spacing of the longitudinal wires commencing at the bottom shall be 4, 4½, 5, 5½, 6, 7, 8 and 9 inches. The bottom wires shall be five inches above the ground and the stay wires shall be spaced twelve inches apart.

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[3] Adopted, Vol. 5, 1904, pp. 386-390, 458, 459; Vol. 7, 1906, pp. 451-456, 478; Vol. 11, Part 2, 1910, pp. 1231-1234, 1246; Vol. 16, 1915, pp. 436-443, 1040.

When used as a hog-tight fence, the bottom wire shall be not over three inches above the ground, with a strand of barbed wire 1½ inches below same.

Class B Fence.

3. A Class B fence shall consist of seven longitudinal smooth galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage.

The spacing of the longitudinal wires, commencing at the bottom, shall be 6½, 7, 7½, 8, 8½ and 9 inches. The bottom wire shall be seven inches above the ground and stay wires shall be spaced eighteen inches apart.

Class C Fence.

4. A Class C fence shall consist of five longitudinal smooth galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage.

The spacing of the longitudinal wires, commencing at the bottom, shall be 7½, 8, 8½ and 9 inches. The bottom wire shall be nine inches above the ground and the stay wires shall be spaced twenty-four inches apart.

Class D Fence.

5. A Class D fence shall consist of five strands of galvanized steel ribbon, smooth, round or barbed wire fencing.

The spacing of the wires, commencing at the bottom, shall be 10, 10, 12 and 12 inches. The bottom wire shall be ten inches above the ground.

The longitudinal wires of all woven wire fencing under Classes A, B and C shall be provided with tension curves to take up expansion and contraction.

MATERIAL.

Wood Posts.

6. Posts shall be made of cedar, locust, chestnut, Bois d'Arc, white oak, mulberry, catalpa or other durable wood native to the locality or of treated timber. They shall be straight and free from splits, rot or other defects.

If sawed or split posts are used, their dimensions shall be at least equal to those hereinafter specified for round posts.

End Posts, Etc.

7. End, corner, anchor and gate posts shall be at least 8 feet long and 8 inches in diameter at the small end, set 3 feet 4 inches in the ground.

Intermediate Posts.

8. Intermediate or line posts shall be at least 7 feet long and 4 inches in diameter at the small end, set 2 feet 4 inches in the ground.

Braces.

9. Braces for end, corner, anchor and gate posts shall be made of intermediate or line posts or 4-inch by 4-inch sawed lumber of a quality equal in durability to that of the posts, and free from large knots, splits, rot and other defects.

Concrete Posts.

10. Concrete posts shall consist of one part Portland cement to four parts run of pit gravel; or one part Portland cement, two parts clean, sharp sand and four parts crushed stone of low absorption or screened gravel. Gravel or broken stone should be of such size as will pass through a ½-inch screen but be retained on a ¼-inch screen.

End Posts, Etc.

11. End, corner, anchor and gate posts shall be at least 8 feet long, 6 inches square at the top and 8 inches square at the base, set 3 feet 4 inches in the ground. The reinforcement shall consist of four ⅜-inch square twisted rods.

Intermediate Posts.

12. Intermediate or line posts shall be at least 7 feet long, 4 inches at the top and 5½ inches at the base, set 2 feet 4 inches in the ground. The reinforcement shall consist of three or four ¼-inch square twisted rods, depending on design of posts.

Braces.

13. Braces for end, corner, anchor and gate posts shall be made of concrete, 4 inches by 4 inches in section, reinforced with four ¼-inch square twisted rods.

Wire.

14. Woven wire fences shall be constructed of basic open-hearth galvanized steel wire. It must stand, without sign of fracture, winding tight around wire of the same size.

Locks.

15. The locks or fastenings at the intersection of the longitudinal and stay wires shall be of such design as will prevent them from slipping either longitudinally or vertically.

Staples.

16. The staples used for fastening the longitudinal wires to the posts shall be made of No. 9 galvanized steel wire. They shall be 1 inch long for hardwood and 1½ inches long for softwood.

Galvanizing.

17. The galvanizing shall consist of an even coating of zinc, which shall withstand one-minute immersion tests in a solution of commercial sulphate of copper crystals and water, the specific gravity of which shall be 1.185 and whose temperature shall be from 60 to 70 degrees Fahrenheit. Immediately after each immersion the sample shall be washed in water and wiped dry. If the zinc is removed, or a copper-colored deposit formed at the end of the fourth immersion, the lot of material from which the sample is taken shall be rejected.

Manufacture.

18. The fence shall be so fabricated as not to remove the galvanizing or impair the tensile strength of the wire.

ERECTION.

End, Corner, Anchor and Gate Posts.

19. End, corner, anchor and gate posts shall be set vertical, at least 3 feet 4 inches in the ground, thoroughly tamped, braced and anchored.

Intermediate or Line Posts.

20. Intermediate or line posts shall be set at least 2 feet 4 inches in the ground and 16½ feet apart.

Post Holes.

21. Holes of full depth shall be provided for all end, corner, anchor and gate posts, even if blasting must be resorted to. For intermediate or line posts, where rock is encountered, not more than two adjacent wood posts shall be set on sills 6 inches by 6 inches by 4 feet long, braced on both sides by 2-inch by 6-inch braces, 3 feet long. Holes shall be provided for all other posts. Posts shall be set with large end down and in perfect line on the side on which the wire is to be strung. After the fence is erected, the tops of the wood posts shall

be sawed off with a one-fourth pitch, the high side being next the wire and 2 inches above it.

Anchoring.

22. Wood end, corner, anchor and gate posts shall be anchored by gaining and spiking two cleats to the side of the posts, at right angles to the line of the fence, one at the bottom, the other just below the surface of the ground. The cleat near the ground surface shall be put on the side next the fence and the bottom cleat shall be put on the opposite side. Intermediate wood posts set in depressions of the ground shall be anchored by gaining two cleats into the side near the bottom of the post, same to be properly spiked.

Cleats, Sills, Etc.

23. All cleats shall be 2 inches by 6 inches by 2 feet long. All sills, braces and cleats shall be made of sawed lumber of a quality equal in durability to that of the posts.

Bracing.

24. Wood end, corner, anchor and gate posts shall be braced by using an intermediate or line post or a piece of 4-inch by 4-inch sawed lumber of a quality equal in durability to that of the posts, gained into the end, corner, anchor or gate post, about 12 inches from the top and into the next intermediate or line post about 12 inches from the ground and be securely spiked. A cable made of a double strand of No. 9 galvanized soft wire looped around the end, corner, anchor or gate post near the ground line, and around the next intermediate or line post about 12 inches from the top, shall be put on and twisted until the top of the next intermediate or line post is drawn back about 2 inches. Four-inch by 4-inch reinforced concrete braces shall be used with concrete posts.

Stretching.

25. Longitudinal wires shall be stretched uniformly tight and parallel; stays shall be straight, vertical and uniformly spaced. Wires shall be placed on the side of the post away from the track.

Stapling.

26. Staples shall be set diagonally with the grain of the wood and driven home tight. The top wires shall be double stapled.

Splicing.

27. Approved bolt clamp splice or a wire splice made as follows may be used: The ends of the wires shall be carried 3 inches past the splicing tools and wrapped around both wires backward from the tool

for at least five turns, and after the tool is removed, the space occupied by it shall be closed by pulling the ends together.

The use of smooth wire in preference to barbed wire is recommended for right-of-way fences.

The use of heavy smooth wire, or a plank at the top of a barbed wire fence, is recommended.

[3] GALVANIZED WIRE FENCING.

(1) The rapid deterioration of modern woven galvanized fence wire is caused by the coating of zinc being too thin and of an uneven thickness. To provide better protection for the wire and a longer life for the fence, it is necessary to secure an increased uniform thickness of zinc coating on the wire. To insure that the galvanizing is intact after the fence has been fabricated, it is recommended that a second coating of zinc be applied to electrically welded fencing after it is manufactured.

(2) It is further recommended that wire which has received a zinc coating which will stand the test prescribed in the specifications be used in the manufacture of fencing, and that in case of electrically welded fencing, the galvanizing be applied after it has been fabricated.

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[3] Adopted, Vol. 7, 1906, pp. 456, 479; Vol. 11, 1910, Part 2, pp. 1234, 1246; Vol. 16, 1915, pp. 440, 1040.

TABLE SHOWING QUANTITY OF MATERIAL NEEDED FOR BARBED WIRE AND BOARD FENCES.

Spacing of Posts.	Posts.			Staples.									Nails.					
	Posts—No. Required.			Staples Required in Pounds—1 Strand of Wire.									Nails Required in Pounds—1 Board.					
				Per Rod.			Per 100 feet.			Per Mile.			Per Rod.		Per 100 feet.		Per Mile.	
	Per Rod	Per 100	Per Mile	1 in.	1¼ in.	1½ in.	1 in.	1¼ in.	1½ in.	1 in.	1¼ in.	1½ in.	8d Com.	10d Com.	8d Com.	10d Com.	8d Com.	10d Com.
8	2.06	12.50	660.0	0.02	0.03	0.03	0.12	0.15	0.18	6.41	7.96	9.57	0.07	0.10	0.39	0.60	20.7	31.5
10	1.65	10.00	528.0	0.02	0.02	0.03	0.10	0.12	0.15	5.13	6.36	7.66	0.07	0.11	0.41	0.64	22.0	33.5
12	1.38	8.33	440.0	0.02	0.02	0.02	0.08	0.10	0.13	4.28	5.30	6.38	0.06	0.09	0.35	0.53	18.3	28.0
14	1.18	7.16	378.0	0.02	0.02	0.02	0.07	0.09	0.11	3.68	4.56	5.48	0.05	0.08	0.30	0.46	15.7	24.0
16	1.03	6.25	330.0	0.01	0.02	0.02	0.06	0.08	0.10	3.20	4.00	4.78	0.05	0.07	0.26	0.40	13.7	21.0
16½	1.00	6.06	320.0	0.01	0.02	0.02	0.06	0.08	0.09	3.11	3.86	4.64						
18	0.92	5.57	294.0	0.01	0.02	0.02	0.06	0.07	0.08	2.86	3.54	4.26						
20	0.83	5.00	264.0	0.01	0.01	0.02	0.05	0.06	0.07	2.56	3.18	3.83						
22	0.75	4.54	240.0	0.01	0.01	0.02	0.05	0.06	0.07	2.34	2.89	3.48						
24	0.69	4.17	220.0	0.01	0.01	0.01	0.04	0.05	0.06	2.14	2.66	3.19						
26	0.64	3.86	204.0	0.01	0.01	0.01	0.04	0.05	0.06	2.00	2.46	2.96						
28	0.59	3.58	189.0	0.01	0.01	0.01	0.04	0.04	0.06	1.84	2.28	2.74						
30	0.55	3.34	176.0	0.01	0.01	0.01	0.03	0.04	0.05	1.71	2.12	2.55						

NOTE — The quantity of nails required is figured on a basis of two nails to a board to each post.

Where posts are 8 feet apart it is figured to use a board 16 feet long.

BARBED WIRE FENCE.

Style of Wire.	Gage of Strand.	Spacing of Barbs.	Weight in Pounds.		
			Per Rod	Per 100 ft.	Per Mile
Baker's Perfect Regular or Cattle, 2 pt	12½	5 in.	0.88	5.31	280.0
" " Thickset or Hog, 2 pt	12½	3 "	0.97	5.87	310.0
Ellwood, Regular or Cattle, 4 pt	12½	5 "	0.94	5.68	300.0
" Thickset or Hog, 2 pt	12½	3 "	1.00	6.06	320.0
" Glidden, Regular or Cattle, 2 pt	12½	5 "	0.92	5.60	295.0
" " Thickset or Hog, 2 pt	12½	3 "	0.99	5.97	315.0
" Junior, Regular or Cattle, 2 pt	12½	5 "	0.88	5.31	280.0
" " Thickset or Hog, 2 pt	12½	3 "	0.94	5.68	300.0
American Glidden, Regular or Cattle, 2 pt	12	5 "	1.00	6.06	320.0
" " Thickset or Hog, 2 pt	12	3 "	1.08	6.54	345.0
Lyman, Regular or Cattle, 4 pt	12	5 "	1.14	6.92	365.0
" Thickset or Hog, 4 pt	12	3 "	1.25	7.58	400.0
Waukegan, Regular or Cattle, 2 pt	12½	5 "	0.87	5.26	277.5
" Thickset or Hog, 2 pt	12½	3 "	0.94	5.68	300.0

BOARD FENCE.

Size of Board.	Ft. B. M.		
	Per Rod	Per 100 ft.	Per Mile.
1 in. x 4 in.	5.50	33.33	1760.0
1 x 6	8.25	50.00	2640.0
1 x 8	11.00	66.67	3520.0
1 x 10	13.75	83.34	4400.0
1 x 12	16.50	100.00	5280.0

NOTE—The material given on the above tables is for one wire or one board high, in order that the material for fences of any number of wires or boards may be figured for different styles of wire and different sizes of boards.

Number of pounds of nails and staples is figured on an allowance of 5 per cent. to 100 per cent. for loss.

SMOOTH STEEL WIRES.

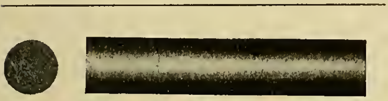
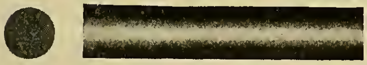
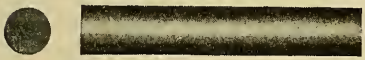
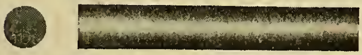
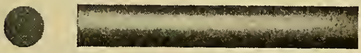
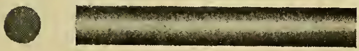
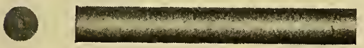
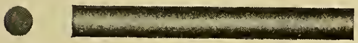
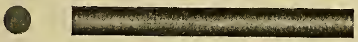
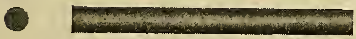
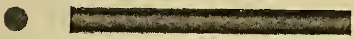
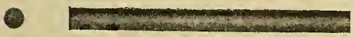
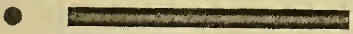
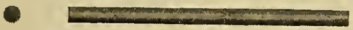
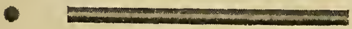
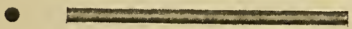
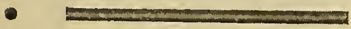
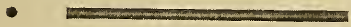
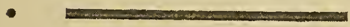
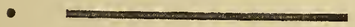
Cuts showing exact sizes of No. 1 to No. 20 gage steel wire by American Steel & Wire Company gage.	Gage.	Lbs. to Mile	Feet to 1 lb.
	1	1121	4.71
	2	968	5.45
	3	833	6.34
	4	707	7.47
	5	599	8.81
	6	514	10.28
	7	439	12.05
	8	367	14.37
	9	306	17.24
	10	255	20.70
	11	202	26.18
	12	154	34.25
	13	118	44.64
	14	89	59.17
	15	72	73.00
	16	55	95.24
	17	41	129.87
	18	31	172.11
	19	24	222.22
	20	17	312.50

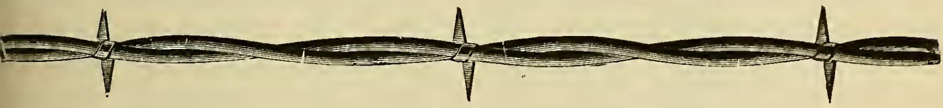
TABLE OF COMPARATIVE SIZES OF WIRE GAGE—IN DECIMALS OF AN INCH.

No. of Wire Gauge.	A. S. & W. Co., or Washburn & Moen.	Birmingham, or Stubb's.	Brown & Sharpe.	English Legal Standard.	Old English, or London.
000000	.460	. . .	. . . . . .	.464	. . . . .
00000	.430	. . . .	. . . . . .	.432	. . . . .
0000	.393	.454	.46000	.400	.4540
000	.362	.425	40964	.372	.4250
00	.331	.380	.36480	.348	.3800
0	.307	.340	.32495	.324	.3400
1	.283	.300	.28930	.300	.3000
2	.263	.284	.25763	.276	.2840
3	.244	.259	.22942	.252	.2590
4	.225	.238	.20431	.232	.2380
5	.207	.220	.18194	.212	.2200
6	.192	.203	.16202	.192	.2030
7	.177	.180	.14428	.176	.1800
8	.162	.165	.12849	.160	.1650
9	.148	.148	.11443	.144	.1580
10	.135	.134	.10189	.128	.1340
11	.120	.120	.09074	.116	.1200
12	.105	.109	.08081	.104	.1090
13	.092	.095	.07196	092	.0950
14	.080	.083	.06408	.080	.0830
15	.072	.072	.05707	.072	.0720
16	.063	.065	.05082	.064	.0650
17	.054	.058	.04526	.056	0580
18	.047	.049	.04030	.048	.0490
19	.041	.042	.03589	.040	.0400
20	.035	.035	.03196	.036	.0350
21	.032	.032	.02846	.032	.0315
22	.028	.028	.02535	.028	.0295
23	.025	.025	.02257	.024	.0270
24	.023	.022	.02010	.022	.0250
25	.020	.020	.01790	.020	.0230
26	.018	.018	.01594	.018	.0205
27	.017	.016	.01419	.0164	.01875
28	.016	.014	.01264	.0148	.01650
29	.015	.013	.01126	.0136	.01550
30	.014	.012	.01002	.0124	.01375
31	.0135	.010	.00893	.0116	.01225
32	.0130	.009	.00795	.0108	.01125
33	.0110	.008	.00708	.0100	.01025
34	.0100	.007	.00630	.0092	.00950
35	.0095	.005	.00561	.0084	.00900
36	.0090	.004	.00500	.0076	.00750
37	0085	. . . .	.00445	.0068	.00650
38	.0080	. . . .	.00396	.0060	.00575
39	.0075	. . . .	.00353	.0052	.00500
40	.0070	. . . .	.00314	.0048	.00450

BAKER PERFECT. TWO POINT.

Flat barbs, short and sharp.

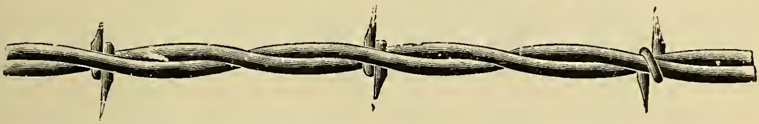
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



ELLWOOD JUNIOR, TWO POINT.

Half-round Barbs, short and sharp.

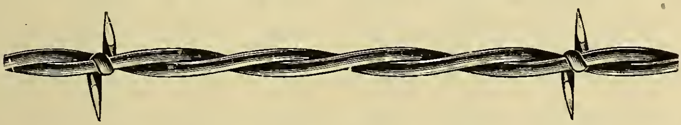
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



WAUKEGAN. TWO POINT.

Half-round Barbs, short and sharp.

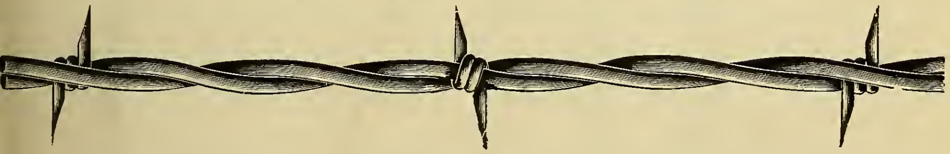
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



AMERICAN GLIDDEN. TWO POINT.

Round Barbs.

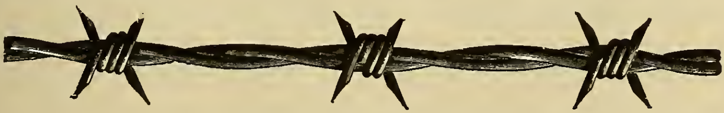
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



LYMAN, FOUR POINT.

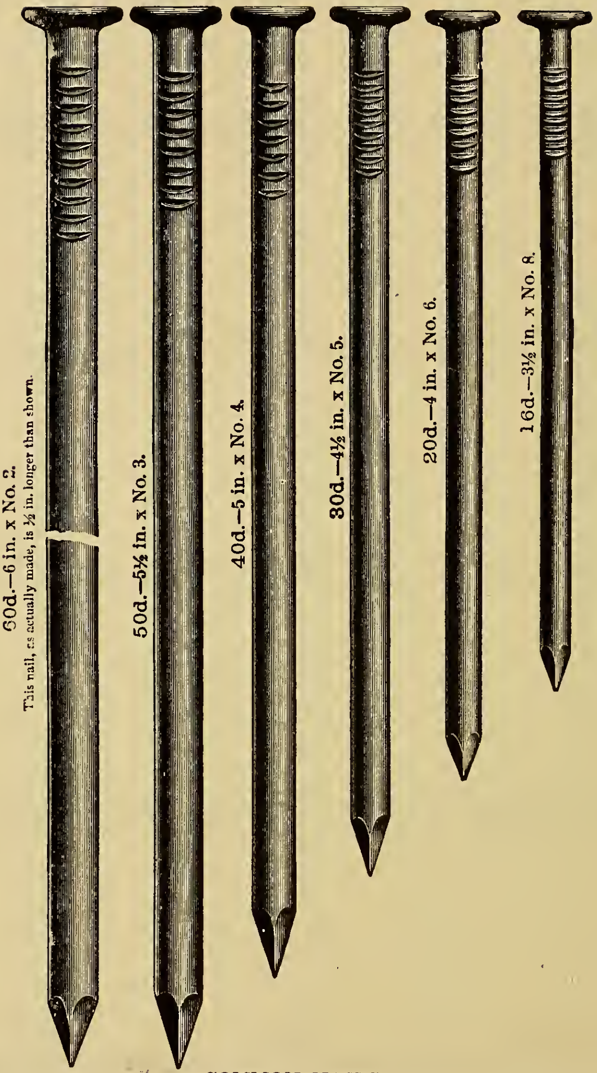
Round Barbs.

Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



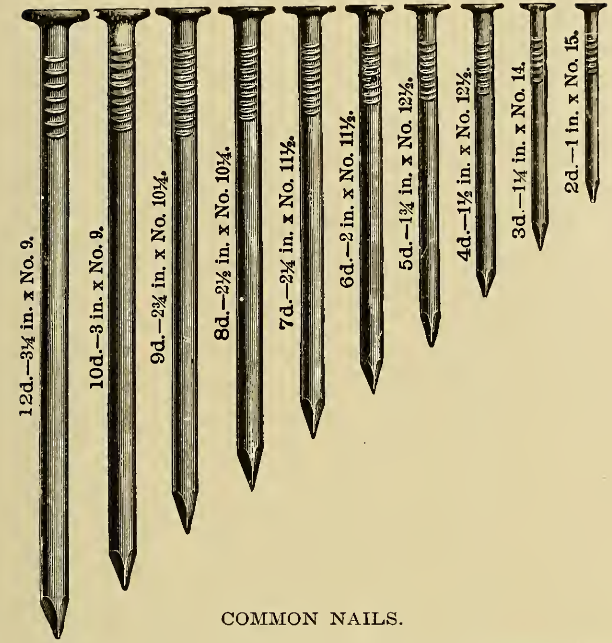
BARBLESS FENCING.

Two-Ply Twisted Galvanized Barbless Fencing. Sizes 11 to 14 inclusive.
3-Ply, 4-Ply, 5-Ply and 6-Ply Twisted Barbless Fencing. Sizes 7 to 14 inclusive.


60d.—6 in. x No. 2.
This nail, as actually made, is ½ in. longer than shown.
50d.—5½ in. x No. 3.
40d.—5 in. x No. 4.
30d.—4½ in. x No. 5.
20d.—4 in. x No. 6.
16d.—3½ in. x No. 8.

COMMON NAILS.

Size.	Length and Gage.		Approximate No. to lb.
16d.	3½ inch	No. 8	49
20d.	4 "	" 6	31
30d.	4½ "	" 5	24
40d.	5 "	" 4	18
50d.	5½ "	" 3	14
60d.	6 "	" 2	11


12d.—3¼ in. x No. 9.
10d.—3 in. x No. 9.
9d.—2¾ in. x No. 10¼.
8d.—2½ in. x No. 10¼.
7d.—2¼ in. x No. 11½.
6d.—2 in. x No. 11½.
5d.—1¾ in. x No. 12½.
4d.—1½ in. x No. 12½.
3d.—1¼ in. x No. 14.
2d.—1 in. x No. 15.

COMMON NAILS.

Size.	Length and Gage.		Approximate No. to lb.
2d	1 inch	No. 15	876
3d	1¼ "	" 14	568
4d	1½ "	" 12½	316
5d	1¾ "	" 12½	271
6d	2 "	" 11½	181
7d	2¼ "	" 11½	161
8d	2½ "	" 10¼	106
9d	2¾ "	" 10¼	96
10d	3 "	" 9	69
12d	3¼ "	" 9	63

1¼ in.

1½ in.

FENCE STAPLES.

Length.	No. to lb.
⅞	120
1	108
1⅛	96
1¼	87
1½	72
1¼	65
2	58

[4] GATES FOR RIGHT-OF-WAY FENCES.

(1) A hinged metal gate is recommended.

(2) The width of farm gates shall be not less than 12 feet, depending upon the size of agricultural machinery in use in the vicinity, or as required by the laws of the States through which the railway operates. The minimum height of farm gates should be 4 feet 6 inches from the surface of the roadway.

(3) Farm gates should be hinged so as to open away from the track, and, if hinged, swing shut by gravity, and the end of the gate opposite the hinged end should lap by the post a sufficient distance to prevent it from being opened by side pressure.

[5] CONCRETE FENCE POSTS.

(1) Concrete fence posts are practical, economical and a suitable substitute for wood.

(2) Reinforcements should be placed as near to surface of posts as possible; ½ inch from surface is best location.

(3) Posts should taper from base to top.

(4) Posts should be not less than 5½ inches at base and 4 inches at top.

(5) Concrete should consist of one part cement to four parts of pit gravel; or one part cement, two parts sand and four parts crushed stone of low absorption, or screened gravel. Gravel or crushed stone should be not less than ¼ inch nor more than ½ inch in size. Concrete should be of a quaking consistency.

(6) Molds should have a jogger or vibratory motion, while concrete is being placed to compact it and smooth up surface of post.

(7) Posts should not be made out of doors in freezing weather. They should not be exposed to sun, and should be sprinkled with water the first eight or ten days after being made to aid curing.

(8) Molds should be carefully oiled or soaped to prevent concrete sticking to them.

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[4] Adopted, Vol. 8, 1907, pp. 528, 533; Vol. 10, 1909, Part 2, pp. 876, 910; Vol. 11, 1910, Part 2, pp. 1234, 1246; Vol. 16, 1915, pp. 440, 1140.

[5] Adopted, Vol. 10, Part 2, 1909, pp. 898, 916, 917; Vol. 11, Part 2, 1910, pp. 1243, 1244, 1246; Vol. 16, 1915, pp. 440, 1040.

(9) Posts should be cured for not less than 90 days, when cured naturally, before being set or shipped.

(10) Posts should be carefully handled and packed in straw, sawdust or other suitable material for shipment.

[6] SNOW FENCES, SNOW SHEDS AND RECOMMENDED METHODS OF SNOW REMOVAL.

Snow is carried by the wind close to the surface of the ground and is deposited in railway cuts on account of the eddies which they cause in the wind. The function of the snow fence is to form artificial eddies on the windward side of the cut at sufficient distance to cause the snow to deposit between the snow fence and the cut.

The location of the drift or eddy depends upon the form of the fence. A tight fence of sufficient height causes the snow to accumulate on the windward side of the fence; an open fence causes the snow to accumulate principally on the leeward side. The distance between the drift and the fence depends upon the height of the fence, the width of the openings between the boards, the velocity of the wind and the character of the snow.

The character of a snow fence and its location for the protection of a given point depends largely upon local conditions, some of which can only be determined by experiment, and for this purpose portable snow fences are recommended.

Where local conditions permit, a permanent snow fence located on the right-of-way is most economical.

Where permanent wood fences are used, the boards should be laid close, where the right-of-way is 50 feet or less from the center of the track; for greater distances, space should be provided between the boards and at a distance of 100 feet; 50 per cent. of the fence should be open space.

The height of permanent board fences depends upon the probable amount of snow. The maximum height, however, should not exceed ten feet.

In most cases local conditions require the use of a portable snow fence. These fences are usually erected in the fields adjoining the right-of-way. They should be set on the windward side of the track at right angles to the prevailing winds; to provide for variations in the direction of the wind, it is sometimes necessary to set the panels in crescent form. For ordinary conditions one line of fence is sufficient. The quantity of snow sometimes, however, requires the use of three or four lines of portable snow fences set parallel and spaced about 100 feet apart. These fences should be removed in the spring so as not to interfere with farming operations.

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[6] Adopted, Vol. 10, Part 2, 1909, pp. 877, 881-887, 915-917; Vol. 11, Part 2, 1910, 1239-1241, 1246; Vol. 16, 1915, pp. 441, 1040.

Hedge fences may be used where the quantity of snow is not too great, and where local conditions, including the economic feature, permit. Properly maintained hedge fences are effective in beautifying the right-of-way.

Stone walls may be used for snow fences where suitable stones for dry masonry walls are available.

Temporary snow fences may be constructed of ties, laid in the form of worm fences.

Railway companies in Northern countries should widen their cuts or provide a slope of 4 to 1 on both sides of the cut for all cuts less than four feet deep.

In the construction of new railways or on grade revision, or trestle filling on existing railways in snow districts, the material should be taken from the side of the cuts. A steam shovel cut on each side is most effective in providing a place for snow to accumulate for ordinary snow conditions, for cuts up to 20 feet in depth.

Salt should be used on switches only during that portion of the winter when the snow melts in daytime and freezes at night.

Where exhaust steam is available, it should be carried about 12 inches below the surface of the ground at points where the accumulation of the ice requires frequent removal during the winter.

SNOW PLOWS.

Rotary snow plows are necessary for quick removal of snow where the depth of the drift exceeds 6 feet and its length exceeds 300 feet or where the natural snow fall has filled deep cuts which cannot be removed by the push plow. Rotary snow plows are sometimes used to advantage in the removal of snow slides in mountain districts.

Push plows should be used for a level fall of snow and minor drifts, whenever the depth is too great to be removed by snow flangers. Snow flangers should be used for the removal of snow where the depth is less than 6 inches over the top of the rail.

SNOW SHEDS.

Snow sheds are expensive to construct and maintain, and the railway should be so located, if possible, as to make their construction unnecessary. Their use should be confined to localities which require protection from mountain snow slides, and they should be constructed of permanent material.

[7] SURFACE STOCK-GUARDS.

GENERAL REQUIREMENTS.

(1) A stock-guard should be so constructed as to avoid projecting surfaces liable to be caught by loose or dragging portions of equipment.

(2) It should be effective against all live-stock, have no parts which would catch or hold animals or unnecessarily endanger employés who pass over it in the discharge of their duties.

(3) It should be reasonable in first cost, durable and easily applied and removed, so as to permit repairs to track at minimum expense.

(4) It should not rattle during passage of trains.

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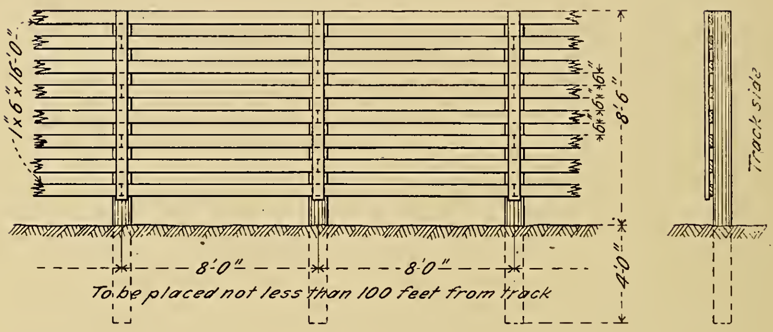
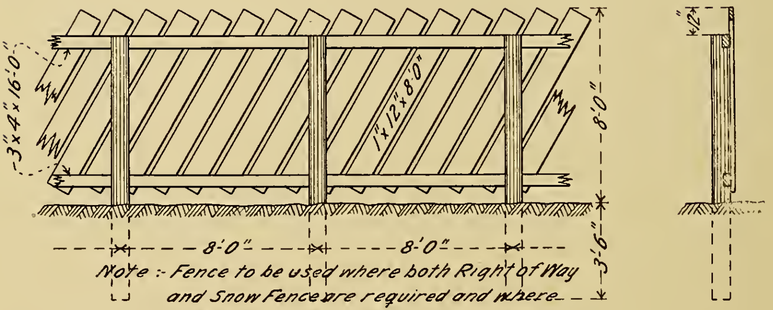
[7] Adopted, Vol. 5, 1904, pp. 387, 390, 459, 461, 462; Vol. 11, Part 2, 1910, 1231, 1246; Vol. 16, 1915, pp. 443, 1041.

PERMANENT SNOW FENCE

OPEN BOARDING.

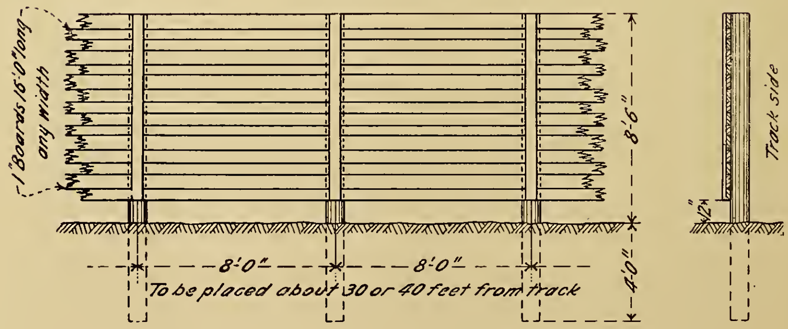


To be placed not less than 100 feet from track



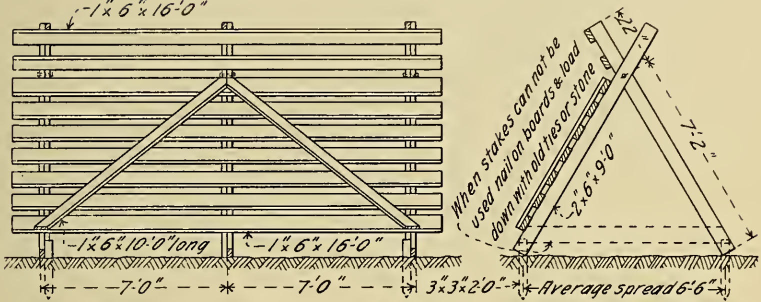
Note :- Fence to be used where both Right of Way and Snow Fence are required and where the Right of Way width is such that the Permanent form will be effective.

CLOSE BOARDING.



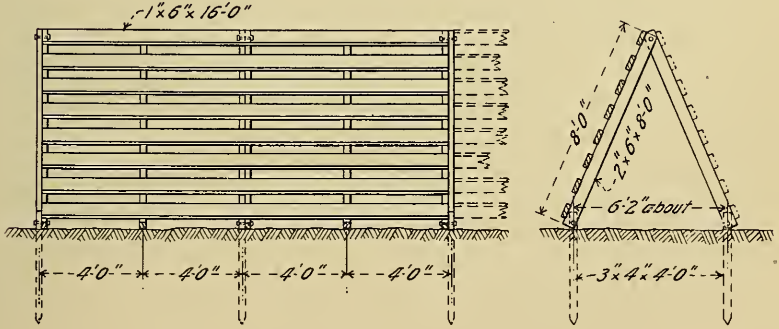
To be placed about 30 or 40 feet from track

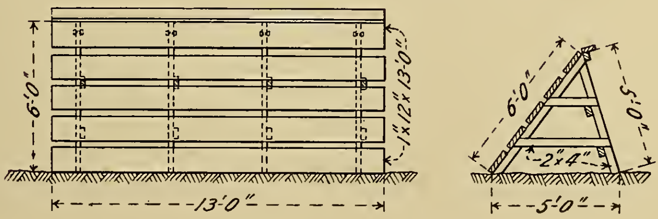
PORTABLE SNOW FENCE.



To be placed not less than 100 feet from track

Length of Section may be reduced to 14 ft. when cost per lin. ft. is not increased.





[8] WOODEN CROSSING SIGNS.

The crossing sign should be made with wooden blades 12 inches wide and 8 feet long, with mitred ends, placed diagonally at an angle of 50 degrees between blades on an 8-inch by 8-inch by 16-foot wooden post. The post should stand 4 feet in the ground. The lower 9 feet of post should be painted black, and the balance white. The blades should be painted white with black letters and one-half inch black border around blades. Border and lettering should be on both sides. Letters should be Egyptian style, 9 inches high, with the exception of connecting terms, as "for the" in the recommended sign, which should be 4 inches high.

[9] TRESPASS SIGNS.

Trespass signs should be made of cast-iron ¼ inch in thickness, borders to be raised ⅛ inch, with slight draught; they should be 1 foot 6 inches deep by 2 feet 6 inches wide, with ⅜-inch diagonal cast ribs on back for stiffness; all signs to have face of letters and borders painted black on white backgrounds; posts and back of signs to be painted black, letters to be raised ⅛ inch with slight draught; 2½-inch wrought-iron pipe, or good second-hand boiler tubes, filled with grout to be used for posts. When concrete or stone foundations are not used, the pipe is to be planted 3 feet 6 inches deep in the ground and a 1-inch diameter gas pipe about 18 inches long to be run through the pipe post about one foot below ground line to keep it from turning. The wording indicated on typical signs indicated, "RAILROAD PROPERTY—TRESPASSING FORBIDDEN UNDER PENALTY OF THE LAW," or "DANGER—DO NOT TRESPASS ON THE RAILROAD," is suggested.

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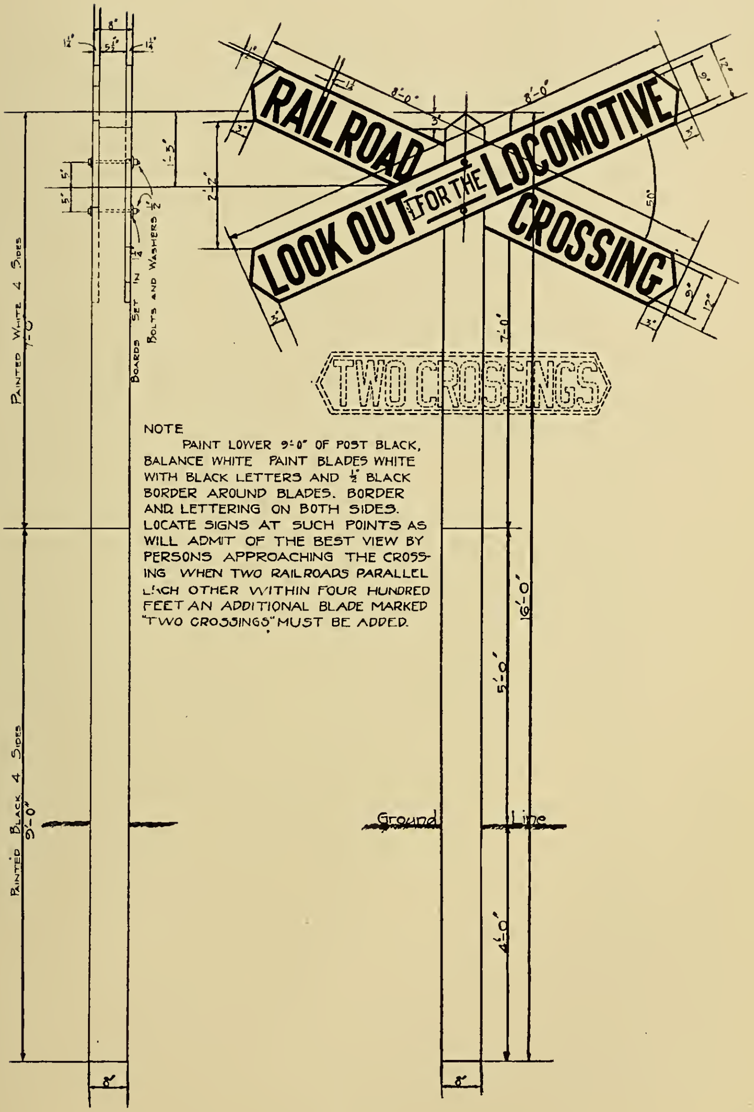
[8] Adopted, Vol. 15, 1914, pp. 872-873, 1137-1148.

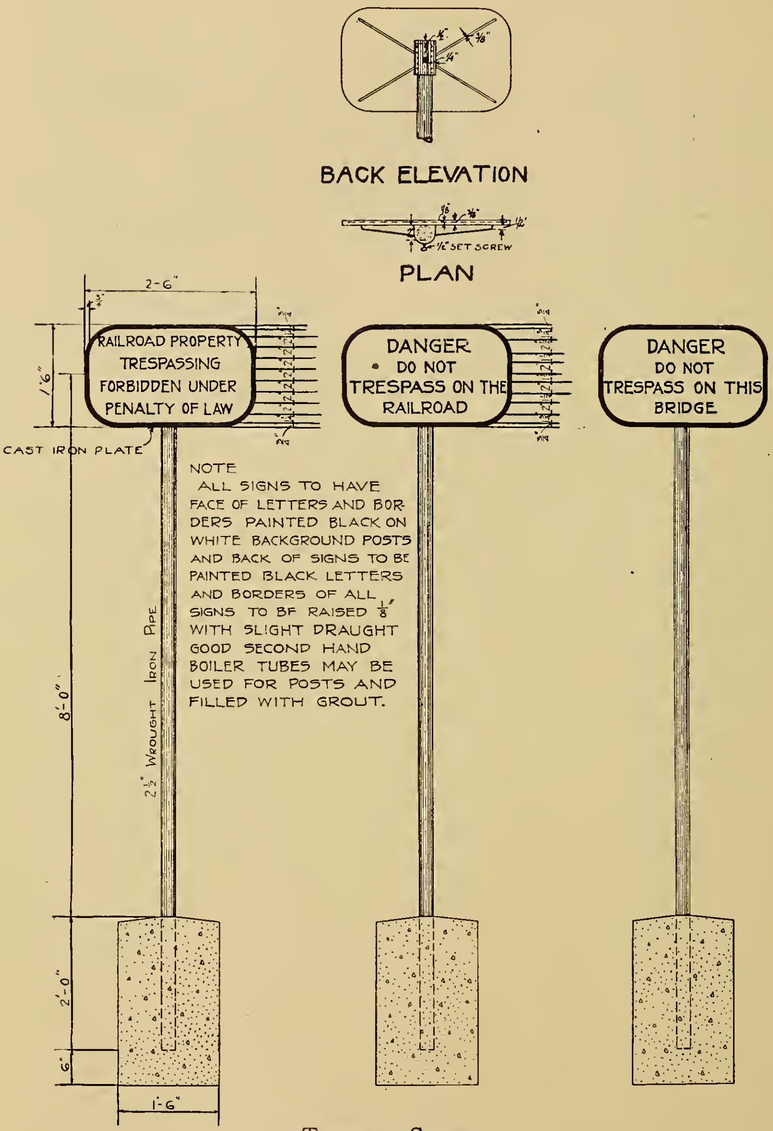
[9] Adopted, Vol. 15, 1914, pp. 880, 881, 1148-1150.



NOTE
PAINT LOWER 9'-0" OF POST BLACK, BALANCE WHITE. PAINT BLADES WHITE WITH BLACK LETTERS AND ½" BLACK BORDER AROUND BLADES. BORDER AND LETTERING ON BOTH SIDES. LOCATE SIGNS AT SUCH POINTS AS WILL ADMIT OF THE BEST VIEW BY PERSONS APPROACHING THE CROSSING. WHEN TWO RAILROADS PARALLEL EACH OTHER WITHIN FOUR HUNDRED FEET AN ADDITIONAL BLADE MARKED "TWO CROSSINGS" MUST BE ADDED.

Crossing Sign.

Note.—Lettering on Crossing Sign is suggestive only, and should conform to local conditions.


BACK ELEVATION
¼"
⅜"
¼"
PLAN
⅛"
⅛"
½"
½" SET SCREW
2-6"
¾"
1'6"
RAILROAD PROPERTY TRESPASSING FORBIDDEN UNDER PENALTY OF LAW
DANGER DO NOT TRESPASS ON THE RAILROAD
DANGER DO NOT TRESPASS ON THIS BRIDGE
CAST IRON PLATE
2½" Wrought Iron Pipe
8'-0"
2'-0"
6"
1'-6"

NOTE
ALL SIGNS TO HAVE FACE OF LETTERS AND BORDERS PAINTED BLACK ON WHITE BACKGROUND POSTS AND BACK OF SIGNS TO BE PAINTED BLACK LETTERS AND BORDERS OF ALL SIGNS TO BE RAISED $\frac{1}{8}''$ WITH SLIGHT DRAUGHT GOOD SECOND HAND BOILER TUBES MAY BE USED FOR POSTS AND FILLED WITH GROUT.

Trespass Signs.

Note.—Lettering on Trespass Sign is suggestive only, and should conform to local conditions.

COMMITTEE X.

SIGNALS AND INTERLOCKING.

[1] DEFINITIONS.

Definitions from Standard Code of The American Railway Association.

Block.—A length of track of defined limits, the use of which by trains is controlled by block signals.

Block Station.—A place from which block signals are operated.

Fixed Signal.—A signal of fixed location, indicating a condition affecting the movement of a train.

Block Signal.—A fixed signal controlling the use of a block.

Home Block Signal.—A fixed signal at the entrance of a block, to control trains in entering and using said block.

Distant Block Signal.—A fixed signal used in connection with a home (and advance) block signal, to regulate the approach thereto.

Advance Block Signal.—A fixed signal used in connection with a home block signal to subdivide the block in advance.

Block System.—A series of consecutive blocks.

Manual Block System.—A block system in which the signals are operated manually.

Controlled Manual Block System.—A block system in which the signals are operated manually, and so constructed as to require the coöperation of the signalmen at both ends of the block to display a clear or a caution block signal.

Automatic Block System.—A block system in which the signals are operated by electric, pneumatic, or other agency actuated by a train or by certain conditions affecting the use of a block.

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[1] Adopted, Vol. 7, 1906, pp. 482, 522-524.

Absolute Block System.—One in which only one train at a time is permitted to occupy this block.

Arm Sweep.—The segment of a circle defining the limits of movement of the arm.

Arm.—A movable arm pivoted to the signal mast, the positions of which give the indications.

Blade.—That part of the arm which, by its form and positions, gives the day signal indications.

Bracket Mast.—A mast mounted on a bracket post.

Bracket Post.—An arrangement of main post with cross-beam, upon which is placed one or two masts for carrying the signal arms, the arrangement of masts determining which track or tracks the signals govern.

Bridge Mast.—A mast mounted on a signal or other overhead bridge.

Chain Wheel.—A device used for changing the direction of a wire line.

Compensator.—A device placed in a pipe or wire line for automatically maintaining a constant length of line under changes of temperature.

Crank.—A device used for changing the direction of a pipe line.

Crank Stand.—A frame in which cranks are supported.

Cross Locking.—A variable shaped block or bar running crosswise of the interlocking machine, actuated by the movements of the locking dog, and by means of which connection is effected between the levers.

Detector Bar.—A bar placed at a switch alongside of and normally below the top of rail, operated in connection with a facing point lock, derailing device or crossing switch, or so that its operation, and consequently that of the lock, will be prevented by the presence of any of the wheels of the train.

Electric Slot.—An appliance for automatically disengaging the signal arm connection from its actuating lever, returning signal arm to "Stop."

Foundation.—A fixed support, usually set in the ground, for carriers, cranks, compensators, wheels, signals and other like devices.

Interlocking Machine.—The primary operating or controlling mechanism of an interlocking plant, placed in the interlocking station, and in which the interlocking feature is effected.

Interlocking Plant.—An arrangement of switch, lock and signal appliances so interconnected or interlocked that one movement must succeed another in a predetermined order.

Interlocking Signals.—The fixed signals of an interlocking plant.

Interlocking Station.—A place from which an interlocking plant is operated.

Jaw.—A device attached to pipe line for connecting same with machine, crank, compensator, or any other device designed for pipe operation.

Leadout.—A combination of cranks, wheels, rocking shafts, pipes and wire, etc., inside and outside of interlocking station by which connections are made between machine and pipe runs.

Lever.—That part of an interlocking machine whose movement effects the operation of its function.

Locking.—A combination of locking dogs and cross-locking or locking dogs and tappets by means of which interconnection is effected between the levers and the order of movement determined.

Locking Bar.—A bar running lengthwise in the interlocking machine to which the locking dogs are attached.

Locking Dog.—A variously shaped block attached to locking bar and through which the interlocking is accomplished.

Mast.—The upright to which the signals are directly attached.

Operated Unit.—A switch, signal, lock or other device in signaling, operated by a lever or other operating means.

Permissive Block System.—One in which two or more trains many occupy a block at the same time.

Pipe Carrier.—A frame with roller support for the pipe line.

Pipe Run.—An assemblage of pipe lines of an interlocking plant, with their carriers and foundations, in a common course.

Rocking Shaft.—A rotating shaft with arms, used for changing the line of motion from one plane to another, perpendicular to the axis of the shaft; also used at slip switches for operating several detector bars and locks.

Route.—A course or way taken by a train in passing from one point to another, especially a customary or predetermined course, or any one of several possible combinations of turnouts or crossovers by which a train may travel between two places.

Screw Jaw.—A threaded jaw used for the purpose of adjustment.

Semaphore Signal.—A device consisting of a movable arm attached to a mast, the indications being given by the position of the arm.

Semaphore Spectacle.—That part of a signal which holds the colored glasses and to which the blade may be attached.

Tappet.—*a.* (In machine with vertical locking.) A bar operated directly or indirectly by the lever or lever latch, which actuates or drives the locking bars and is locked by them.

b. (In machine with horizontal locking.) A pivot or swing dog attached to the locking bar, and actuated or locked by the cross-locking.

Wire Carrier.—A frame with roller support for the wire line.

Wire Run.—An assemblage of wire lines of an interlocking plant, with their carriers and foundations, in a common course.

[2] CONVENTIONAL SIGNS OR SYMBOLS FOR SIGNALS AND INTERLOCKING.

(See under Records and Accounts, pp. 410-421.)

[3] TRAIN-ORDER SIGNALS.

The American Railway Association's third and fourth requisites of installation of interlocking plants are: (3) "Signals if practicable (to be) either over or upon the right of and adjoining the track to which they refer." (4) "Semaphore arms that govern (to be) displayed to the right of the signal mast as seen from an approaching train."

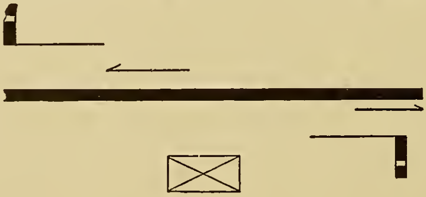

Fig. 1.

It is recommended that these two requisites be adopted with reference to *fixed* train-order signals for all number of tracks from one up, as illustrated in Figs. 1 and 2.

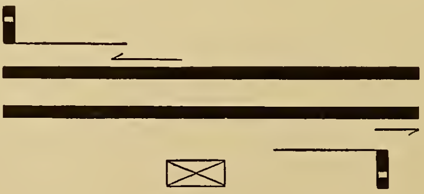

Fig. 2.

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[2] Adopted, Vol. 15, 1914, pp. 80-92, 1010.
[3] Adopted, Vol. 4, 1903, pp. 295-297, 299, 315-346.

Where it may be deemed advisable, for special reasons, to use a bracket post, no more than two uprights should be placed on the bracket. One of these uprights may be a stub to indicate a track not signaled. In other words, no more than one track should intervene between a bracket signal post and the track for which its left upright carries the signal arm. (See Fig. 3.)

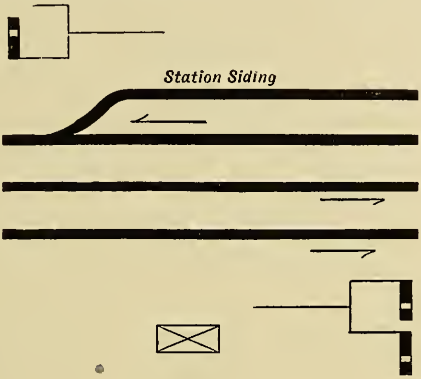

Fig. 3.

It seems proper to recognize the current practice of using flags by day and hand lamps by night. It is important, though, that a regular place for displaying these be predetermined, and there seems to be no better way than to place a regular flag socket with hook on the side of the signal station toward the direction of the approaching train, and convenient for the operator to reach from one of the windows.

The definition of "Train-Order Signal" is as follows: "A fixed signal of two indications, which in the stop position informs the engineman and conductor that they are to receive orders at the telegraph office, and in the clear position announces that there are no orders for them."

This Association recommends as good practice a fixed train-order signal, with a sweep of arm of 90 degrees from the horizontal.

[4] MANUAL AND CONTROLLED MANUAL BLOCK SIGNALS.

(1) The location recommended for the Manual and Controlled Manual Block Signal is on a mast alongside and to the right of the track on which are run the trains that it governs, as shown in Fig. 4; but, in the case of more than two tracks, when it is impracticable to

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[4] Adopted, Vol. 6, 1905, pp. 518, 527, 550, 551.

spread them apart for this purpose, then the recommended location is on a bracket post, as in Fig. 5, or on a bridge over the tracks, as in Fig. 6.

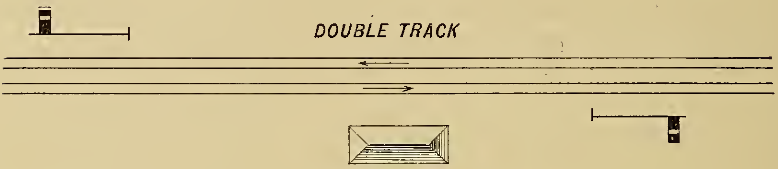

Fig. 4.

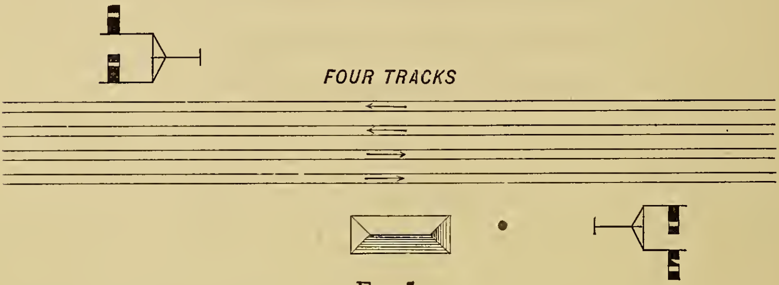

Fig. 5.

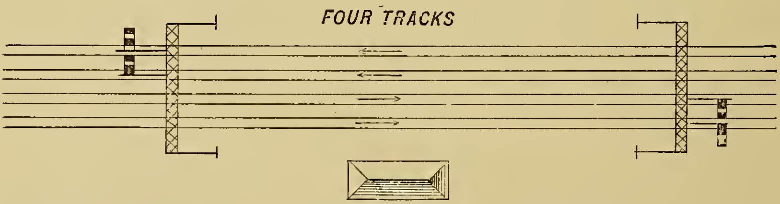

Fig. 6.

(2) It is good practice to make use of the electric slot to send the block signal to normal position, "Stop," as the train passes.

[5] LOCATION OF MANUAL BLOCK SIGNALS.

(1) The arrangement shown in Fig. 7 is good practice for use on single-track line as a train-order signal and a block signal. Distant signals may be used.

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[5] Adopted, Vol. 7, 1906, pp. 481, 482, 485, 539, 540.

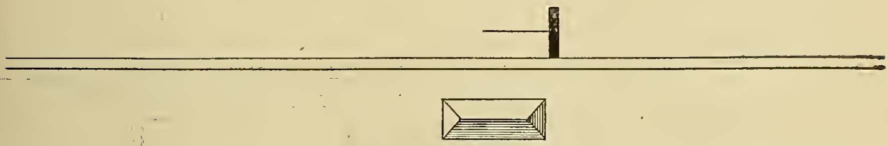

Fig. 7.

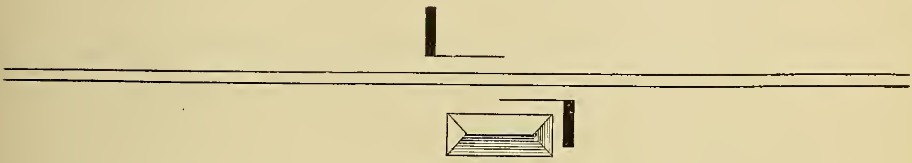

Fig. 8.

(2) The arrangement shown in Fig. 9 should be adopted when necessary to subdivide the block, and track circuit should be used in the subdivided block to control the rear signal.

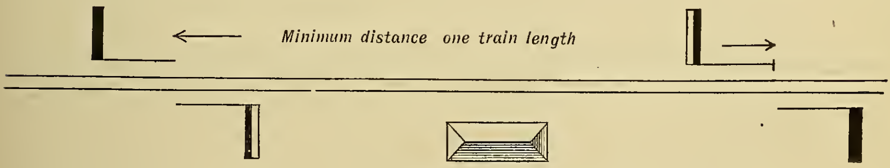

Fig. 9.

(3) The double-track arrangement, as shown in Figs. 10 and 11, is recommended as good practice.

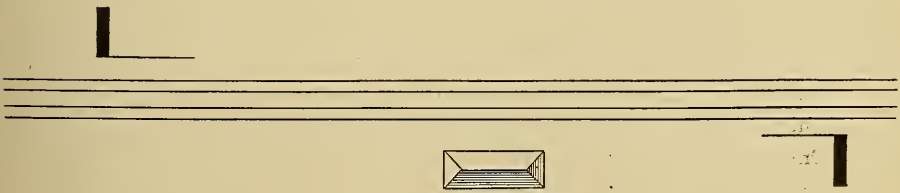

Fig. 10.

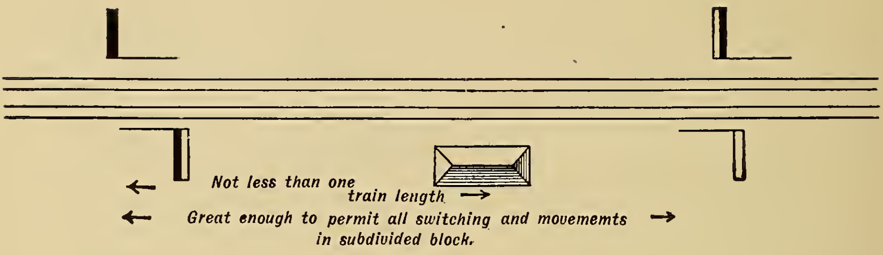
Not less than one train length
Great enough to permit all switching and movememts in subdivided block.

FIG. 11.

[6] INDICATIONS CONFERRING OR RESTRICTING RIGHTS.

The adoption of the following principles is recommended in view of the recent trend of the development of the art, and should not be understood as condemning present practice.

(1) It is recommended that the following principles of giving indications govern in formulating a signal system:

(a) That on all signals conferring or restricting rights, a red light shall be the night indication for "stop;" a yellow light shall be the night indication for "caution;" and a green light the night indication for "clear."

(b) That the day indication of semaphore signals be given in the upper right-hand quadrant.

(c) That the semaphore arm horizontal shall indicate "stop;" inclined upward 45 degrees, "caution;" and inclined upward 90 degrees, "proceed."

[7] DIVISION OF EXPENSE OF INSTALLATION, RENEWAL AND MAINTENANCE OF JOINT INTERLOCKING PLANTS.

The division of expense of the installation, renewal and maintenance of joint interlocking plants should be divided on a unit basis according to the following table:

NAME OF OPERATED UNIT.	VALUE.
One Signal Arm	1
One Pair Switch Points	1
One Derail	1
One Pair Movable Point Frogs	1

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[6] Adopted, Vol. 8, 1907, pp. 84, 97, 104.
[7] Adopted, Vol. 8, 1907, pp. 72, 84, 91-95.

One 50-ft. Detector Bar, with or without Locks	1
One Scotch Block	1
One Torpedo Machine	1
One Power Signal	1
ELECTRIC LOCKING.	
For Each Electric Lock	1
ANNUNCIATORS AND INDICATORS.	
One Route	1

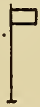
[8] SIGNAL INDICATIONS AND ASPECTS.

MEANS OF DESIGNATING STOP SIGNALS OPERATED UNDER AUTOMATIC BLOCK SYSTEM RULES.

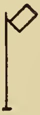
Scheme No. 1.

FUNDAMENTALS.

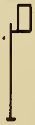
1. Stop................................



2. Proceed with caution..................



3. Proceed..............................



As means of designating stop signal operated under automatic block system rules, the following are suggested:

1. The use of a number plate; or
2. The use of a red marker light below and to the left of the active light; or
3. The use of a pointed blade, the blades or other signals giving the stop indication having square ends; or
4. A combination of these distinguishing features.

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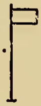
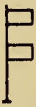
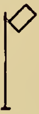
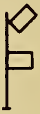
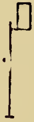
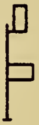
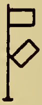
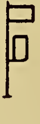
[8] Adopted, Vol. 14, 1913, pp. 71-75, 1046.

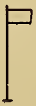
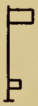
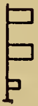
Scheme No. 2.

	Fundamentals.	Supplementary Indications.
1. Stop		
2. Proceed with caution		
3. Proceed		
4. Proceed at low speed		
5. Proceed at medium speed		

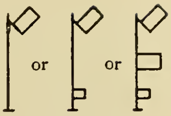
As means of designating stop signals operated under automatic block system rules, the following are suggested:

1. The use of a number plate; or
2. The use of a red marker light below and to the left of the active light; or
3. The use of a pointed blade, the blades of other signals giving the stop indication, having square ends; or
4. A combination of these distinguishing features.

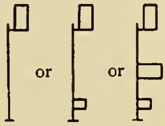
Having in view the practice of indicating diverging routes by several arms on the same mast, the following, to establish uniformity in this practice, is recommended:

1. Stop..  or  or  or

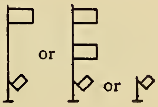
2. Proceed with caution........................



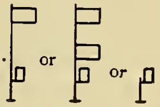
3. Proceed....................................



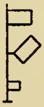
4. Proceed with caution on low-speed route......



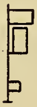
5. Proceed on low-speed route...................



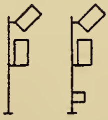
6. Proceed with caution on medium-speed route...



7. Proceed on medium-speed route...............



8. Reduce to medium speed... ....



As means of designating stop signals operated under automatic block system rules, the following are suggested:

1. The use of a number plate; or
2. The use of a red marker light below and to the left of the active light; or
3. The use of a pointed blade, the blades of other signals giving the stop indication having square ends; or
4. A combination of these distinguishing features.

[9] REQUISITES FOR SWITCH INDICATORS, INCLUDING CONVEYING INFORMATION ON CONDITION OF THE BLOCK TO CONDUCTORS AND ENGINEMEN.

The following is an amplification of the adjunct in the Standard Code and requisites for switch indicators which have been adopted by the Railway Signal Association:

SWITCH INDICATORS.

Amplification of Adjunct (C), Automatic Block System, The Standard Code of The American Railway Association.

(C) Indicators at main track switches to indicate, on roads of two or more tracks, one or more of the following:

(a) Whether or not a train is approaching.

(b) Whether or not that portion of the block between the switch and the next Home Block Signal in advance is clear.

(c) Whether or not the next Home Block Signal in the direction of approaching trains is at Stop.

REQUISITES OF INSTALLATION.

(1) Switch indicators, if practicable, located:

(a) At main track switches connecting with tracks on which trains may clear main tracks, and in which either there are no derails or diverging switches, or the derails or diverging switches are connected with the main track switches.

(b) At independently operated derails or diverging switches in tracks on which trains may clear main tracks.

(c) At points from which switches of crossovers between main tracks are operated, where both switches are operated from the same point.

(d) At independently operated switches of crossovers between main tracks, the indicator at the switch in one track operated in connection with the other track.

(2) Switch indicators that cannot be identified by their locations, marked with the designations of the tracks in connection with which they are operated.

(3) The connections of switch indicators used to indicate whether or not a train is approaching, so arranged that an indicator will indicate the approach of a train that has reached a point at least such a distance in the rear of the second block signal in the direction of approaching trains that, if the switch is thrown at the moment when a train reaches that point, the Caution-signal will be displayed in time to be observed

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[9] Adopted, Vol. 16, 1915, pp. 75, 76, 1034.

by the engineman; and will continue so to indicate until the train passes the Home Block Signal in the rear of the switch or, approximately, the clearance point of the switch when the switch is more than ...... feet in advance of the Home Block Signal. The distance of the point at which the approach of a train is first indicated will be determined in each case by the grade, speed of trains, view of the signal or other local conditions.

[10] LIST OF THE FINDINGS, CONCLUSIONS, STANDARDS AND SPECIFICATIONS CONTAINED IN THE MANUAL OF THE RAILWAY SIGNAL ASSOCIATION.

(Published for the information of the members of the American Railway Engineering Association.)

TEXT.

Automatic Block Signals.
  Alternating Current, A. C. Propulsion, Specifications.
  Alternating Current, D. C. Propulsion, Specifications.
  Alternating Current, Steam Railways, Specifications.
  Direct Current, Specifications.

Automatic Train Control, Requisites of Installation and Adjuncts (The American Railway Association).

Battery, Primary.
  Caustic-Soda Cell, Specifications.
  Coppers, Gravity Battery, Specifications.
  Zincs, Gravity Battery, Specifications.

Battery, Storage.
  Concrete Box for, Specifications.
  Lead-type, Description of.
  Lead-type, Electrolyte for, Specifications.
  Lead-type, New Electrolyte for, Specifications.
  Lead-type, Charged from Primary Cells, Instructions for Operation.
  Lead-type, in Block-signal Service, Instructions for Operation.
  Lead-type, at Interlocking Plants, Instructions for Operation.
  Portable Lead-type, Directions for Installation.
  Portable Lead-type, Instructions for Operation.
  Portable Lead-type, Specifications.
  Stationary Lead-type, Directions for Installation.
  Stationary Pure-lead-type for Signaling, Specifications.

Bells.
  Annunciator, Specifications.
  Highway Crossing, D.C. Vibrating, Specifications.

Cables
  Aerial Braided, for 660 volts or less, Specifications.
  Armored Submarine, for 660 volts or less, Specifications.
  Armored, Submarine, for 2,200 volts, Specifications.
  Lead-covered, for 660 volts or less, Specifications.
  Lead-covered, for 2,200 volts, Specifications.

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[10] Adopted, Vol. 16, 1915, pp. 77-84, 1026-1034.

Channel Pins, Specifications.

Circuit Nomenclature and Written Circuits.

Concrete, Portland Cement, Specifications.

Conduit.
  Fiber, Three Inches in Diameter with One-fourth-inch Wall, Specifications.
  Pipe, Steel, Specifications.
  Pipe, Wrought Iron, Specifications.
  Vitrified Clay, Specifications.
  Vitrified Clay, Installation of a System, Specifications.

Copper Sulphate, Specifications.

Crossarms.
  Wood, Specifications.
  Braces and Heel and Toe Bolts for, Specifications.
  Steel Pins for, Specifications.
  Through Bolts and Double-arm Bolts for, Specifications.

Definitions of Technical Terms.

Drawbridges.
  Protection by Electro-pneumatic Interlocking.
  Protection by Mechanical Interlocking.

Engine, Gasoline, with Fuel and Water Tanks, Specifications.

Fiber, Hard, Specifications.

Fuses, Specifications.

Galvanizing Iron or Steel, Specifications (American Railway Engineering Association).

Generators.
  D.C. Electric, Specifications.
  A.C. Electric, Specifications.

Glass, Signal (See Roundels).

Impedance Bonds.
  11,000 Volts, A.C. Propulsion, Specifications.
  D.C. Propulsion, Specifications.

Impregnation Treatment of Coils and Windings, Specifications.

Interlocking.
  Electric, Specifications.
  Electro-pneumatic, Specifications.
  Mechanical, Specifications.

Iron.
  Castings, Gray, Specifications.
  Castings, Malleable, Specifications.
  Wrought, Bars, Specifications.

Low-voltage Electric Operation of Track Switches, Requirements.

Oil.
  Illuminating, Specifications.
  Transformer, Specifications.

Performance, Signal, Forms for Recording (see Drawings).

Petrolatum for Use in Impedance Bonds, Specifications.

Petroleum Asphaltum, Specifications.

Pipe.
  One-inch Soft Steel Signal, Specifications.
  One-inch Wrought Iron Signal, Specifications.

Poles, Eastern White Cedar, Specifications.

Push Buttons, Specifications.

Pushes, Floor, Specifications.

Relays, Lifting Armature Neutral-type D.C., Specifications.

Releases, Mechanical and Electric, Specifications.

Roundels, Lenses and Slides, Specifications.

Rules.
- Governing Maintenance of Block Signals.
- Governing Signal Foremen.
- Governing Signal Maintainers.
- Governing Signal Supervisors.

Signal, D.C. Motor Semaphore, Specifications.

Signal Indications, Principles of.

Signaling Practice—Signal Indications and Aspects (American Railway Engineering Association).

Steel, Machinery, Specifications.

Switchboards.
- Slate, for Battery Charging, Specifications.
- Slate and Equipment for A. C. Signal System, Specifications.

Switch Indicators, Purposes and Requisites of Installation.

Tape.
- Friction, Specifications.
- Rubber Insulating, Specifications.

Transformers.
- Single-phase Line, Oil-immersed Self-cooled Outdoor-type, 4,400 volts or less, Specifications.
- Single-phase Track, 250 vovlts or less, Specifications.

Trunking, Wood, Specifications.

Voltage Rangers for Signal Work.

Wire.
- Bonding, Copper-clad Steel, Specifications.
- Bonding, Galvanized E.B.B., Specifications.
- Line, Copper-clad Steel, 30 per cent. Conductivity, Hard-drawn, Specifications.
- Line, Double-braided Weatherproof Galvanized B.B., Specifications.
- Line, Double-braided Weatherproof Hard-drawn Copper, Specifications.
- Messenger, Galvanized, Specifications.
- Messenger, Recommended Sags for.
- Magnet, Enameled Copper, Specifications.
- Rubber Insulated (Mineral-matter Rubber-compound) Copper, for 660 volts or less, Specifications.
- Rubber Insulated, Inspection Report, Form for.
- Rubber Insulated, Insulation Resistances.
- Rubber Insulated, Machine for Insulating, Type of.
- Steel Signal, Galvanized, Specifications.

Wire Crossings.
- Crossings of Wires or Cables of Telegraph, Telephone, Signal and Other Circuits of Similar Character over Steam Railroad Rights-of-Way, Tracks or Lines of Wires of the Same Classes, Specifications (Association of Railway Telegraph Superintendents).
- Overhead Crossings of Electric Light and Power Lines, Specifications (American Railway Engineering Association).

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COMMITTEE XI.

RECORDS AND ACCOUNTS.

[1] DEFINITIONS.

RECORDS.—Information or data in graphical, tabular or statement form relating to physical characteristics, conditions, cost and such other information as may seem desirable for record.

REPORTS.—The medium through which information is transmitted from one to another official and from which records and accounts are prepared or compiled in the filing office.

ACCOUNTS.—Statements required to enable payments to be made for labor performed and material furnished, or to establish the detail, total and comparative cost of work and various classes of expenses.

LEDGER ACCOUNTS FOR INDIVIDUAL PIECES OF WORK.—Statements kept in ledger form in order to establish the detail, total and comparative cost of any particular work or class of expenses.

CONVENTIONAL SIGNS.—Symbols, such as a mark, character, abbreviation or letter selected or sanctioned by general agreement and used to indicate upon a map or plan certain forms, conditions and objects both natural and structural.

PROGRESS PROFILE.—A graphical record of the progress of work prepared at stated periods.

TRACK CHART.—A diagram showing the physical characteristics of track and roadbed.

RIGHT-OF-WAY MAP.—A plat representing the actual location and dimensions of the property, rights or franchises that are owned or controlled by a railway company.

TRACK MAP.—A map used primarily for showing existing physical conditions, including tracks, bridges, buildings, water service and mains, leases, station facilities and all of the physical and operating features.

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[1] Adopted, Vol. 7, 1906, pp. 279, 318; Vol. 9, 1908, pp. 663, 664, 667, 668, 677, 686.

[2] FILING DUPLICATE RECORDS IN SEPARATE LOCALITIES FOR PROTECTION IN CASE OF FIRE.

Duplicate copies of record books and maps, particularly right-of-way maps, should be kept in quite widely separated localities, so that the trouble and expense of reproducing the same will be greatly reduced in case of fire or accident.

[3] BRIDGE DEPARTMENT FORMS.

(1) The following standard forms are considered essential and recommended as the special forms for a regular working Maintenance of Way Bridge Department:

Monthly Bridge Material Report	M. W. 1100
Maintenance of Way Department Tool Report	M. W. 701
Structure Report	M. W. 1102
Current Bridge Inspection Report	M. W. 702
Summary Current Bridge Inspection Report	M. W. 703
General Bridge Inspection Report	M. W. 704

(2) In Bridge Inspection there should be a clear distinction made between Current Inspection and General Inspection. The purpose of the Current Inspection is to keep the structure in safe condition, to discover any defects and to report the same promptly, so that repairs can be made before the safety of the structure is affected. It is important that a simple record should be made while at the bridge and that the superior officer be kept advised of all such inspections, whether made by a Bridge Mechanic, Gang Foreman, Division Bridge Inspector, Master Carpenter, or others.

The purpose of the General Inspection, frequently called the annual inspection, although in many cases conducted semi-annually or even quarterly, is not only to check the maintenance work of the division organization, but to make a more careful investigation of important bridges and structures on the entire road, and, further, to ascertain and determine what extensive repair work or renewal work should be done in the following working season.

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[2] Adopted, Vol. 5, 1904, pp. 286, 371, 377 (see Vol. 2, 1901, p. 322); Vol. 6, 1905, pp. 658, 668.

[3] Adopted, Vol. 5, 1904, pp. 237, 372-375; Vol. 6, 1905, pp. 656, 657, 668; Vol. 11, 1910, pp. 1100, 1103, 1141; Vol. 15, 1914, pp. 924, 1157,; Vol. 16, 1915, pp. 786, 1085.

(3) The general forms of the railway should be used in all departments, including the Bridge Department, as far as applicable; for example, one form for reporting time should be used in all departments, the form being designed accordingly.

(4) Bridge records, when properly kept up to date in an accurate manner, will prove of the highest value to railways and are essential for any system of complete and proper bridge records. However, forms in connection with bridge records are not specially necessary for a Bridge Department, but are necessary generally for the compilation of records for several departments, and hence these forms are not recommended as standard special Bridge Department forms.

(5) Numerous minor special forms are used on all railways for reporting information necessary to keep bridge records up to date, but such forms should be regulated by each individual railway according to its peculiar requirements, and hence no standard forms for this purpose are recommended.

Size 8x13 inches. Form M. W. 1100.

A. B. & C. R. R. Co.

________________________DIVISION

MONTHLY BRIDGE MATERIAL REPORT

______________________________ Month of________________________19___

(Gang or District.)

KIND OF MATERIAL	UNIT	ON HAND FIRST OF MONTH	RECEIVED	DISPOSED OF		ON HAND END OF MONTH	REMARKS
				USED	SHIPPED AWAY		
← 2.″0 →	←0.″5→	←0.″7→	←0.″7→	←0.″7→	←0.″7→	←0.″7→	← 2.″0 →
THREE SPACES PER INCH							

The above statement is correct:

....
Foreman of Bridges.

Correct:..
Master Carpenter

Back of Form M. W. 1100.

A. B. & C. R. R. Co.

....
(Gang or Dist.)

..............DIVISION

MONTHLY
BRIDGE MATERIAL REPORT

For..........Ending..........19..

Foremen are required to make the above report..........and forward same to Master Carpenter, who will, after examining, approve it and forward to Division Engineer.

To be filed in the office of Division Engineer.

SPECIFICATIONS FOR FORM M. W. 1100.

Form as here shown. Size 8x13 inches. Vertical lines, red; horizontal lines, blue.

Size 8x13 inches

Form M. W. 701

A. B. & C. R. R. Co.

MAINTENANCE OF WAY DEPARTMENT TOOL REPORT

____
(Gang or District)

____________________________DIVISION. For__________________ending ________________19___

(Insert list of tools standard with road using forms.)

TOOLS	ON HAND _____1ST	RECEIVED	SENT TO SHOP FOR REPAIRS	BROKEN OR WORN OUT	ON HAND	TOOLS	ON HAND _____1ST	RECEIVED	SENT TO SHOP FOR REPAIRS	BROKEN OR WORN OUT	ON HAND
← 1.″5 →	← 0.″5 →	← 0.″5 →	← 0.″5 →	← 0.″5 →	← 0.″5 →	← 1.″5 →	← 0.″5 →	← 0.″5 →	← 0.″5 →	← 0.″5 →	← 0.″5 →

THREE SPACES PER INCH

The above statement is correct:

....
Foreman of Bridges.

....
Master Carpenter

Back of Form M. W. 701.

A. B. & C. R. R. Co.

....
(Gang or Dist.)

...............DIVISION

MAINTENANCE OF WAY DEPARTMENT TOOL REPORT

For.........Ending............19..

Foremen are required to make the above report ....and forward same to Master Carpenter, who will, after examining, approve it and forward to Division Engineer.

To be filed in the office of Division Engineer.

SPECIFICATIONS FOR FORM M. W. 701.

Form as here shown. Size 8x13 inches. Vertical ruling, red; horizontal ruling, blue.

Size 8x13 inches. **Form M. W. 1102.**

A. B. & C. R. R. Co.

____________________DIVISION

STRUCTURE REPORT

The following material was used____
(State location of structure definitely.)

____

Work authorized______________ Commenced______________ Finished______________

KIND OF MATERIAL	UNIT	QUANTITY	PRICE	AMOUNT	
← 4.''2 →	← 0.''7 →	← 1.''0 →	← 0.''5 →	← 0.''8 →	← 0.''8 →
THREE SPACES PER INCH					
KIND OF LABOR	HOURS				
OTHER CHARGES					

The above statement is correct:

....
Division Engr.

Back of Form M. W. 1102.

A. B. & C. R. R. Co.

...............Division

STRUCTURE REPORT

For..........Ending..........19..

SPECIFICATIONS FOR FORM M. W. 1102.

Form as here shown. Size 8x13 inches. Vertical ruling, red; horizontal ruling, blue.

Size 8x13 inches. Form M. W. 703.

A. B. & C. R. R. Co.

SUMMARY CURRENT BRIDGE INSPECTION REPORT.

For________________________________19___

Bridge No. or Structure	Kind of Structure	Day of Month Insp't'd	Condition	Action taken or Recommendation

Road may insert list of numbers, etc.

Date_______________________190_____ ____________________________

NOTE – This report to include all bridges and structures inspected during the period covered by the report.

Back of Form M. W. 703.

A. B. & C. R. R. Co.

..............DIVISION

SUMMARY CURRENT

BRIDGE INSPECTION REPORT

For..........Ending............19..

Foremen are required to make the above report..........................and forward same to Master Carpenter, who will, after examining, approve it and forward to Division Engineer.

To be filed in the office of Division Engineer.

SPECIFICATIONS FOR FORM M. W. 703.

Form as here shown. Size 8x13 inches. Vertical ruling, red; horizontal ruling, blue.

Size 11x8 inches. Form M. W. 704.

A. B. & C. R. R.			GENERAL BRIDGE	
________________Division				
From________________		To________________		
Bridge No. or Structure	Location	Kind of Structure	Bridge Data	Date Inspected

SPECIFICATIONS FOR FORM M. W. 704.

Form as here shown. Size of page, 5½x8 inches. To be issued in book form for field use, and on separate sheets for office use. Vertical ruling, red; horizontal, blue.

INSPECTION REPORT.

For____________________________________

Inspected by____19

General Condition, Description of work required, Recommendations.

(This report to be signed also by those composing inspection party.)

Size 5¼ x 8 inches. Form M. W. 702.

Report No.________

A. B. & C. R. R. Co.

________________Division

CURRENT BRIDGE INSPECTION REPORT

I have to-day inspected____________________________________

at ____

and find its condition as follows:

____

____

The following work is required to maintain structure in good condition:

____

____

The following work must be done to keep the structure safe:

____

____

____

Inspector.

Date,________________________191

Note.—Make separate report for each bridge or structure inspected. Send report to the______________of the Division. Report by telegraph to the______________and the Superintendent of the Division all serious defects that require attention.

SPECIFICATIONS FOR FORM M. W. 702.
Current Bridge Inspection Report.
Form as here shown. Size 5¼x8 inches. All letters black.

(Road may provide one additional page on which to insert list of members of the structures to be inspected, the inspector to check off the different items of the structure inspectd.)

COVER PAGE OF FORM M. W. 1103, PROVIDING FOR SIGNATURE OF FOREMAN AND SUPERVISOR.

Form M. W. 1103

A. B. & C. R. R. CO.

*SUBDIVISION No.*__________

TIME ROLL

of

*SECTION No.*__________ *or*____________________
(Name or Number of Gang)

____________________ *Month of*________________ *19*
HEADQUARTERS

I hereby certify that the within returns are correct:

Examined and found correct: ____________________
FOREMAN

*Supervisor of*____________________

SPECIFICATIONS FOR FORM M. W. 1103.

Size of book, 5x8 inches. Form as shown, cover to be of three-ply manila paper; book proper to be on yellow paper; printing to be in black. Book to contain 12 pages. (Form shown is about one-half reduction.)

DAILY RECORD

RECORD OF TIME

NAME	CHECK No.	OCCUPATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

1. Spell names correctly. Write out first name and give middle initial. Enter check number in check number column.
2. Write "Paid by Certificate," when men have been so paid. If hired again, enter name a second time.

INSTRUCTIONS.

1. Enter the information daily.

2. Read the instructions at the bottom of pages 2 and 3.

3. Show under each day the hours of work of each kind done, including work done by Foreman.

4. The Summary on pages 14 and 15 must show all the work done during the month. It is obtained by collecting the work done each day. Show separately work done on main tracks, sidings, new or construction work of all kinds and for individuals or other companies.

5. The total hours each day must agree with the totals shown on pages 2, 3, 4, 5, 6 and 7.

6. The total of hours in Summary must agree with the total on page 7.

F TIME.

Form M. W. 1103.

OR MONTH OF____________________19

18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL HOURS	RATE OF PAY		DEDUCTIONS	AMOUNT	WHERE PAYABLE
															Per Month	Per Hour			

3. Amounts due each man must be in even five (5), or ten (10), cents.

4. Time of monthly men, not working a full month: Multiply the rate per month by the number of days worked (including Sundays and holidays) and divide by the total number of days in the month.

RECORD OF WORK DONE ON DAYS OF THE MONTH

DAY	KIND OF WORK AND WHERE PERFORMED	HOURS
1		
2		
3		
4		
5		

RECORD OF WORK DONE ON DAYS OF THE MONTH

DAY	KIND OF WORK AND WHERE PERFORMED	HRS.
31		

SUMMARY OF WORK DONE FOR MONTH

ITEMS	DISTR.	HOURS	RATE	AMOUNT	

I certify the foregoing to be correct,

________________________*Foreman.*

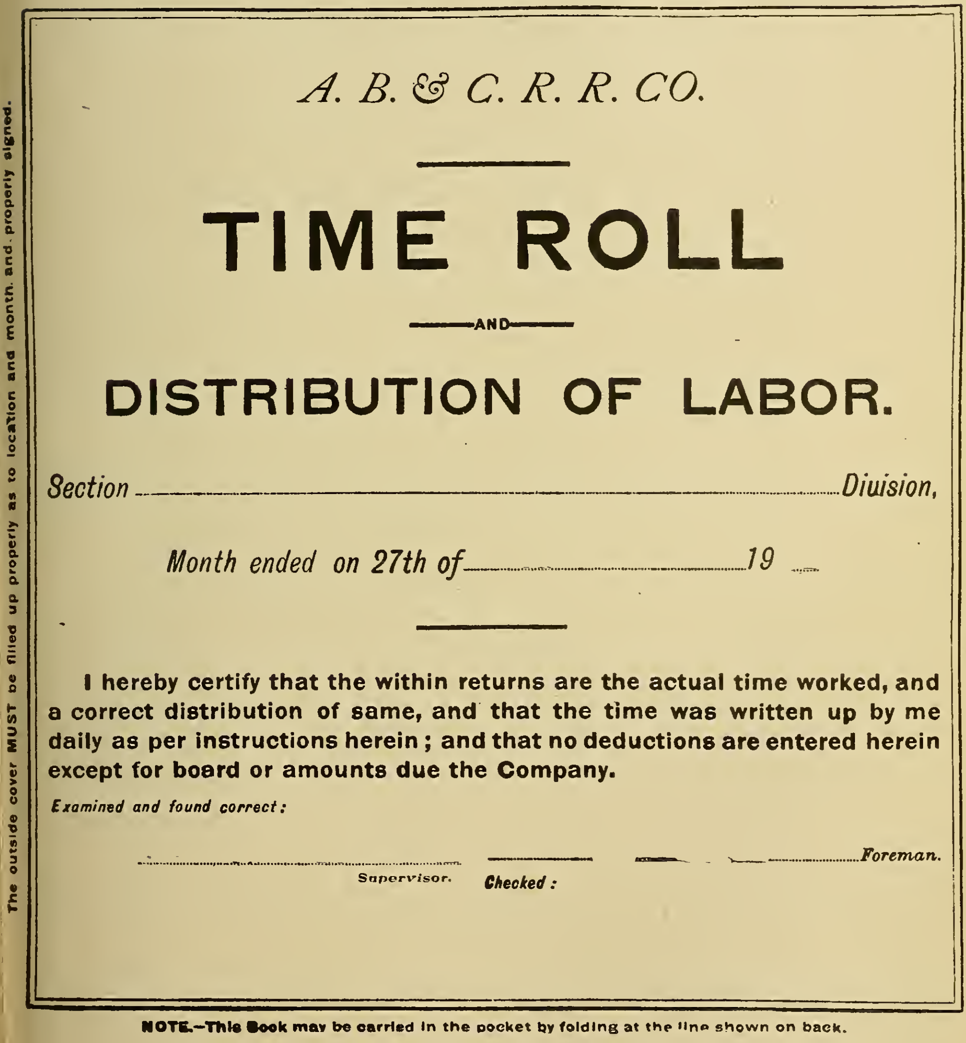
Examined and approved,

________________________*Supervisor.*

NOTE.—Spaces to be provided for 31 days.

Size 8½x9 in. Form M. W. 1104.

FORM TO BE USED BY SECTION AND EXTRA GANGS.



A. B. & C. R. R. CO.

TIME ROLL

AND

DISTRIBUTION OF LABOR.

Section .... *Division,*

Month ended on 27th of .... *19* ....

I hereby certify that the within returns are the actual time worked, and a correct distribution of same, and that the time was written up by me daily as per instructions herein; and that no deductions are entered herein except for board or amounts due the Company.

Examined and found correct:

.... *Foreman.*

Supervisor. *Checked:*

The outside cover MUST be filled up properly as to location and month, and properly signed.

NOTE.—This Book may be carried in the pocket by folding at the line shown on back.

FORM FOR DISTRIBUTION SUMMARY—

DISTRIBUTION OF LABOR PERFORMED AS SHOWN ON PAGES 1 AND 2.

DISTRIBUTION OF LABOR.	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11

To be made out by Foreman.

TO BE MADE OUT BY FOREMAN.

..........................*Division.* *Month ending 27th of*..........................*19* __

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	TOTAL TIME	Account Number
																	2
																	4
																	9
																	10
																	11
																	12
																	13
																	14
																	15
																	16
																	17
																	18
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																	29
																	30
																	31
																	32
																	33
																	34
																	35
																	36
																	37
																	39-40-41
																	51 to 65
																	92
																	105-118-119
																	135
																	145

This column must be in accordance with the established Classification of Accounts.

To be made out by Accountant.

PAGE FOR SHOWING DETAILS OF WORK DONE BY TRACK

EXPLANATIONS.

REPAIRS WATER STATIONS			REPAIRS FUEL STATIONS			WORK EQUIPMENT REPAIRS		
DATES	LOCATIONS	TIME	DATES	LOCATIONS	TIME	DATES	GIVE NAME AND NUMBER	TIME

HANDLING COMPANY'S MATERIAL—COAL, WOOD, ICE OR ENGINE SAND

DATES	STATIONS	TIME	DATES	STATIONS	TIME	DATES	STATIONS	TIME

CLEANING STOCK PENS AND CHUTES			CLEANING STOCK CARS			TENDING SWITCH LAMPS			
DATES	STATIONS	TIME	DATES	STATIONS	TIME	DATES	LOCATIONS	TIME	

REPAIRS OF INTERLOCKERS			REPAIRS BLOCK SIGNALS			REPAIRS TO OTHER SIGNALS		
DATES	LOCATIONS	TIME	DATES	LOCATIONS	TIME	DATES	LOCATIONS	TIME

SIDINGS TAKEN UP.

DATES	LOCATIONS	TIME	DATES	LOCATIONS	TIME	DATES	LOCATIONS	TIME

ALL OTHER WORK ON EXISTING SIDINGS

DATES	LOCATIONS	NATURE OF WORK	TIME	DATES	LOCATIONS	NATURE OF WORK	TIME

DEPARTMENT ON WORK NOT CHARGEABLE TO TRACK WORK.

EXPLANATIONS.

BRIDGES, TRESTLES AND CULVERTS, PERMANENT				BRIDGES, TRESTLES AND CULVERTS, TIMBER							
DATES	NUMBERS	TIME		DATES	NUMBERS	TIME		DATES	NUMBERS	TIME	
		Main Tracks	Side Tracks			Main Tracks	Side Tracks			Main Tracks	Side Tracks

OVER AND UNDER GRADE CROSSINGS				HIGHWAY GRADE CROSSINGS				CATTLE GUARDS AND SIGNS			
DATES	NUMBERS	TIME		DATES	NUMBERS	TIME		DATES	NUMBERS	TIME	
		Main Tracks	Side Tracks			Main Tracks	Side Tracks			Main Tracks	Side Tracks

REPAIRS OF BUILDINGS.

DATES	KIND OF BUILDING AND WHERE LOCATED	TIME	DATES	KIND OF BUILDING AND WHERE LOCATED	TIME	DATES	KIND OF BUILDING AND WHERE LOCATED	TIME

REPAIRS AND RENEWALS OF EQUIPMENT.

ENGINES			PASSENGER CARS			FREIGHT CARS		
DATES	GIVE NAME AND NUMBER	TIME	DATES	GIVE NAME AND NUMBER	TIME	DATES	GIVE NAME AND NUMBER	TIME

DETAILS OF CHARGES TO OTHER THAN OPERATING ACCOUNTS.

10

FOR USE OF ACCOUNTANT

DETAIL OF CHARGES TO CONSTRUCTION, SUNDRY DISTRIBUTIONS AND ADDITIONS AND BETTERMENTS

ADDITIONS AND BETTERMENTS				SUNDRY DISTRIBUTIONS			
	AMOUNT				AMOUNT		
CONSTRUCTION	AMOUNT						

Cover page for Form M. W. 1105. This form to be used by B. & B., Fence, Telegraph, Signal, Water Service, and all other gangs except Section and Extra Gangs.

Size 8½x9 inches. Form M. W. 1105.

The outside cover **MUST** be filled up properly as to location and month and properly signed.

A. B. & C. R. R. CO.

TIME ROLL

AND

DISTRIBUTION OF LABOR

Gang No...............................

______________________________ **DEPARTMENT**

Month ending on ______________ *of* ______________ *19*

I hereby certify that the within returns are the actual time worked, and a correct distribution of same, and that the time was written up by me daily as per instructions herein; and that no deductions are entered herein except for board or amounts due the Company.

Examined and found correct:

....*Foreman.*

....
Supervisor.

Checked:

NOTE—This Book may be carried in the pocket by folding at the line shown on back.

TIME RECORD FOR FORMS M. W. 1104 AND 1105.

Page A.

.... —**TIME ROLL.** **Department.**

	NAME.	Occupation	28		29		30		31		1		2		3		4		5		6		7		8		9		10		11		12	
			A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.
1																																		
2																																		
3																																		
4																																		
5																																		
6																																		
7																																		
8																																		
9																																		
10																																		
11																																		
12																																		
13																																		
14																																		
15																																		
16																																		
17																																		
18																																		
19																																		
20																																		
	TOTAL																																	
The person checking this book will sign his initials and Time of Inspection in the spaces below total line.																																		

TIME RECORD FOR FORMS M. W. 1104 AND 1105—Continued.

Page B.

__________Division. Month ended 27th of__________19__

13		14		15		16		17		18		19		20		21		22		23		24		25		26		27		TOTAL TIME	RATE OF PAY		AMOUNT OF WAGES		DEDUC-TIONS		REMARKS
A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.		Per Month	Per Hour					

DISTRIBUTION PAGE FOR LABOR PERFORMED BY INDIVIDUALS WHERE

REPORT OF LABOR PERFORMED by..

	DESCRIPTION OF WORK PERFORMED Give numbers of all bridges, location and description of all buildings, location of bridge watchmen, location of fences, etc., etc.	28		29		30		31		1		2		3		4		5		6		7		8		9		10		11		12	
		A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.
1																																	
2																																	
3																																	
4																																	
6																																	
6																																	
7																																	
8																																	
9																																	
10																																	
11																																	
12																																	
13																																	
14																																	
15																																	
16																																	
17																																	
18																																	
19																																	
20																																	
	TOTAL,																																

GANG IS NOT ALL EMPLOYED ON SAME PIECE OF WORK.

Form M. W. 1105.

__________Division. Month ended 27th of__________19

13		14		15		16		17		18		19		20		21		22		23		24		25		26		27		TOTAL TIME	RATE OF PAY		AMOUNT OF WAGES		DEDUCTIONS		REMARKS
A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.		Per Month	Per Hour					

TIME RECORD OF TEAMS EMPLOYED.

Form M. W. 1104 and 1105.

RECORD OF TEAMS EMPLOYED. Section No...

	NAME.	Number of Teams	28		29		30		31		1		2		3		4		5		6		7		8		9		10		11		12	
			A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.
1																																		
2																																		
3																																		
4																																		
5																																		
6																																		
7																																		
8																																		
9																																		
10																																		
11																																		
	TOTAL																																	

TIME RECORD OF TEAMS EMPLOYED.

Forms 1104 and 1105.

.... Division. Month ended 27th of 19

13		14		15		16		17		18		19		20		21		22		23		24		25		26		27		TOTAL TIME	RATE OF PAY		AMOUNT OF WAGES		DEDUCTIONS		If Amount Exceeds $150.00 it should be paid by Voucher
A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.		Per Month	Per Hour					
																																					DRAFT or VOUCHER No.
																																					"
																																					"
																																					"
																																					"
																																					"
																																					"
																																					"
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																																					"
																																					"
																																					"

DISTRIBUTION SUMMARY (TO BE MADE OUT IN

Form M. W. 1105.

SUMMARY OF DISTRIBUTIONS.

DESCRIPTION OF WORK PERFORMED.	AMOUNTS CHARGEABLE											
The description given hereunder must agree with that shown on preceding pages.	1 and 2		3 and 4		5 and 6		7 and 8		9 and 10		11 and 12	

SUPERVISING OR ACCOUNTING OFFICE).

FROM PAGES				
13 and 14	15 and 16	17 and 18	19 and 20	21 and 22

SUMMARY OF DISTRIBUTIONS.

AMOUNTS CHARGEABLE					
23 and 24	25 and 26	27 and 28	29 and 30	31 and 32	33

PAGE FOR EXPLAINING OVERTIME AND ERRORS IN RECORDING TIME.

Forms M. W. 1104 and 1105.

EXPLANATION OF OVERTIME.

EXPLANATION OF ERRORS.

INSTRUCTIONS ON INSIDE COVER OF FORMS M. W. 1104 AND 1105.

INSTRUCTIONS.

TO FOREMEN:

1. On the "Time Roll' the name of the foreman should be entered on the first line, and those of his men should be arranged thereunder in alphabetical order of their surnames. One given name of each man must be written in full.

2. Time worked should be entered as directed by superior officer.

3. All entries must be made by indelible pencil.

This book must be carried by the foremen and submitted for inspection to Roadmaster or Supervisor whenever request is made therefor. If foreman should leave his gang he should leave his book with assistant foreman, if one is employed, so book can be checked.

4. Distribution of time should be entered daily on pages 1 to 40 inclusive. Separate line should be used for each piece of work and time should be shown opposite each under correct date. Total of distribution for the month as shown on detail pages must agree with total amounts shown under "Amount of Wages" on pages A and B.

5. If a man is given an order for his time, write "Time Given" in the column headed "Remarks" on page B, on the same line with his name and time.

A. B. & C. R. R. Co.

Form M. W. 1112.

Statement of Labor performed on { Section No.______ or by __________________________ ________________ DIVISION Gang Located at __________________________ on Sub. Div. No. ____________________ for month of ______________ 19___

No.	NAME	OCCUPATION	LOCATION	TIME EMPLOYED																														Total Time	Rate		Amount Earned	DEDUCTIONS			Amt. Payable	REMARKS
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	24	24	25	26	27	29	30	31		Mo	Hr		For	In favor of	Amt.		
			See I. C. C. 1914.																																							
		Total Hours																																								
		Total Wages																																								

Accounts Chargeable																														Total Charges	*	*	*	*	*	*	*	
MAINTENANCE OF WAY AND STRUCTURES:																																						
1 Superintendence																																						
2 Ballast																																						
5 Other Track Material																																						
6 Roadway and Track																																						
7 Removal of Snow, Sand and Ice																																						
8 Tunnels																																						
9 Bridges, Trestles and Culverts																																						
10 Over and Under-Grade Crossings																																						
11 Grade Crossings, Fences, Cattle-Guards and Signs																																						
12 Snow and Sand Fences and Show Sheds																																						
13 Signals and Interlocking Plants																																						
14 Telegraph and Telephone Lines																																						
16 Buildings, Fixtures and Grounds																																						
17 Docks and Wharves																																						
18 Roadway Tools and Supplies																																						
19 Work Equipment—Repairs																																						
Total M. of W. & S.																																						
MAINTENANCE OF EQUIPMENT:																																						
Total M. of E.																																						
TRANSPORTATION EXPENSES:																																						
72 Station Supplies and Expenses																																						
78 Engine House Expenses—Yard																																						
87 Engine House Expenses—Road																																						
95 Train Supplies and Expenses																																						
96 Interlockers, Block and Other Signals—Operation																																						
98 Drawbridge Operation																																						
99 Clearing Wrecks																																						
Total Transp. Expenses																																						
GENERAL EXPENSES:																																						
Total General Expenses																																						
Total Operating Expenses																																						
FUEL AND SUPPLIES:																																						
Total Fuel and Supplies																																						
OPEN ACCOUNTS:																																						
Individuals and Companies																																						
Total Open Accounts																																						
GENERAL ACCOUNTS:																																						
Additions																																						
Betterments																																						
Outside Operations																																						
Acct. No. Sub. Acct. No.																																						
Acct. No. Sub. Acct. No.																																						
Total Outside Operations																																						
OTHER GENERAL ACCOUNTS																																						
Real Estate Expenses and Repairs																																						
Total Other General Accts.																																						
GRAND TOTAL																																						

This can be modified to conform with Classification of Expense.

I hereby certify that the time made by each employe named herein and distribution to accounts chargeable correspond with actual work done as reported to me daily by Foreman ____________________ on Form______, and I have examined Foreman's Pocket Record of Time, Form ______, and find that total time and amount earned by each employe is correct.

____
Supervisor

Examined and approved:

____

* Distribute Amounts chargeable to Main Line, Roads Merged, etc., and Branch Roads in these columns.

☞ See Instructions on back of Form.

Back of Form M. W. 1112.

INSTRUCTIONS.

1. Enter full name of each employe in each gang, and give proper occupation and location in respective columns. The time made by each employe must be recorded daily and show total time made at close of month. The time made during month, calculated at authorized rates, will give amount earned.

2. Supervisors must distribute time daily to the proper accounts, chargeable according to information given on Foreman's Report, Form ......, and care must be exercised so that at close of month the "Total Charges" will balance with the "Total Wages."

3. At the close of month Supervisors will apportion expense to Main Line, Roads Merged, etc., and Sundry Branch Roads, in accordance with the instructions of the road using.

4. This report must be carefully checked with Foreman's Pocket Time Book Form ......, and if there is any difference it must be located and proper adjustment made before this report is forwarded to ...... for approval.

5. This report, after being properly certified by Supervisor and examined and approved by ...., will be forwarded to the .... on the ...... of the month.

Form M. W. 1106.

A. B. & C. R. R. Co.

SUB-DIVISION No.______

Daily Report of Time Worked by Track Gang on Section No.________________________________

or________________________Gang at______________________Location____________________

For_____________Day of______________________19____

NAME	IDENTIFICATION NUMBER	OCCUPATION	RATE		DESCRIPTION OF WORK DONE								TOTAL TIME	AMOUNT To be filled in by Supervisor.		REMARKS
			Mo.	Hrs.												
To be filled in by Supervisor.		Total Time " Wages														

Time and Extensions Entered by________________

I certify that the persons named above were employed in the service of the A. B. & C. R. R. Co. as specified, and the time worked is correct.

Examined by______________.

_________________Foreman.

See Instructions on back.

Back of Form M. W. 1106.

INSTRUCTIONS.

1. This Report will be made by the Foreman and forwarded to Supervisor on first train after completion of each day's work.
2. Care must be taken to write distinctly, give correct description of work done in space provided, and that the actual hours engaged by each man on each class of work is entered in proper column opposite his name. Foreman will also enter his own time in hours (total only).
3. Total time made daily by each employe must agree with his time as shown by Foreman's pocket time book, Form..........
4. Foreman will enter his name first, then follow with balance of gang.
5. Give below briefly a statement showing quantity of work done..................

....

....

....

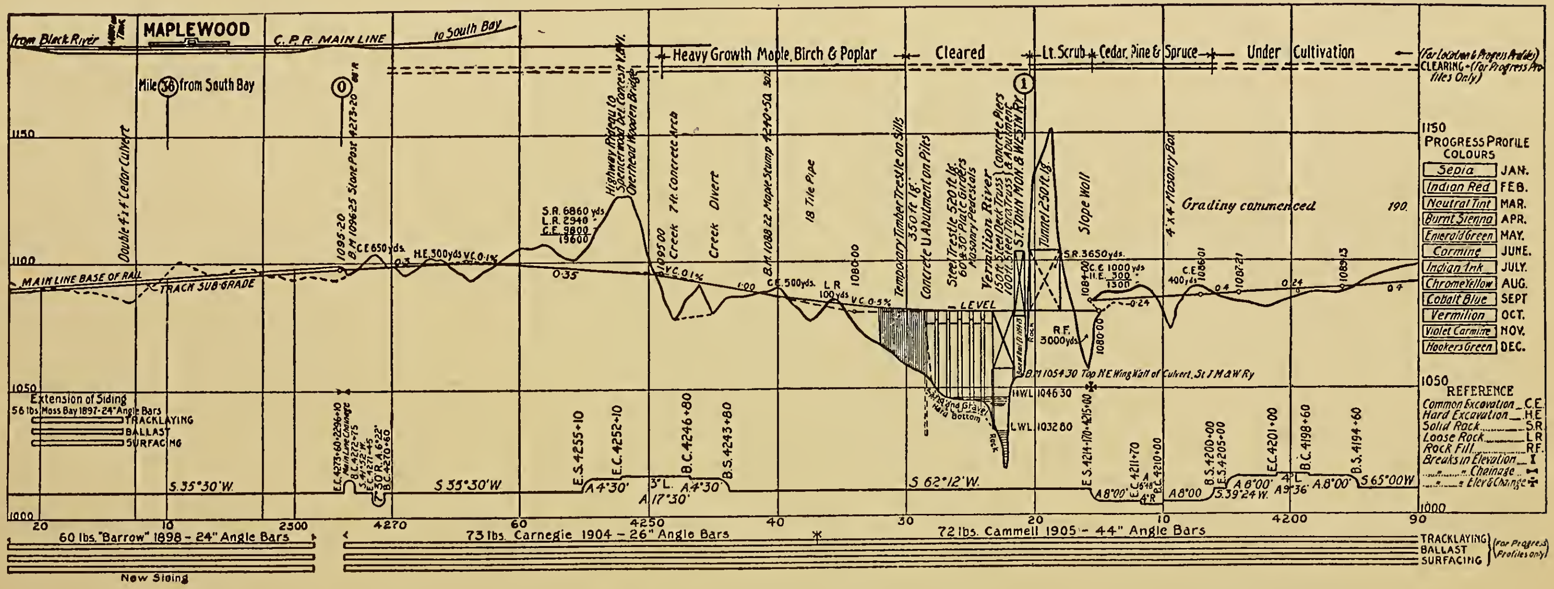
....

....

....

Form M. W. 2001

PROGRESS PROFILE.



[5] RECORD COST OF WORK.

Size 14x17 in. Form M. W. 1111.

A. B. & C. R. R. Co.

General Description............................ Location..................

Authorization No.......... Total Amount Authorized $..................

Actual Cost $............ Work Began.......................................

Work Completed............................. Remarks...................

....

	Quantity	Unit		Price	Value	Total	Grand Total

SPECIFICATIONS FOR FORM M. W. 1111.

Size 14x17 in.; unruled; to be printed on medium bond paper (white).

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[5] Adopted, Vol. 9, 1907, 665-667, 669, 672, 694.

Size 8x13 Inches. Form M. W. 2100

[6] ESTIMATE FOR TRACK CONSTRUCTION.

A. B. & C. R. R. Co.

TRACK ESTIMATE ....DIVISION

Work..

.... At..

Date of Estimate..............................19.......

Total Length of Track in Ft......................................

Total Clearance Length ....Ft

Maximum Curvature ....Degrees....................Min

Width of Roadbed on Fills....................Ft., in Cuts....................Ft.

Maximum Grade Away From Main Track....................%.

Maximum Grade in Direction of Main Track....................%

Made by

.... (Title.)

ITEM	DESCRIPTION	AMOUNT	UNIT PRICE	COST	CREDITS FOR OLD MATERIAL	Chargeable to:
Waylands	Acres	Ac.				
Clearing	Squares (100 Ft. x 100 Ft.)	Sq.				
Moving Track		Ft.				
" Buildings						
" Fence	Kind	Rods				
Grubbing	Squares (100 ft x 100 ft.)	Sq.				
Grading	Cu Yds of	Cu. Yds				
Pipes Kind	Size	Lin. Ft.				
Drain Tile "	"	" "				
Culverts "	"					
Bridges "		Lin. Ft.				
Ties "	(Class) Treated					
"	" "					
Rail	Lbs per Yd	Tons				
"	" " "	"				
"	" " "	"				
Angle Bars	Class Lb., Length	Pairs				
" "	" " "	"				
" "	" " "	"				
Bolts	Size	Kegs				
"	"	"				
Nut Locks Kind		Boxes				
Spikes		Kegs				
Rail Braces						
Tie Plates						
*Ballast (in Place)	QUARRY PIT	Cu. Yds,				
†Turnouts Complete						
" "						
Turnouts without Switch Ties						
" " " "						
Switch Ties	For No. Turnout	Sets				
" "	" " "	"				
Slip Switches	Wt Lb., No.					
Derails Complete	Kind					
Railroad Crossings	Wt. Lb., Style					
Railroad Crossing Timbers		Ft. BM				
Cattle-Guards (state kind)		Sets				
Road Crossings		Ft. BM				
Signs (state kind)						
Fences (state kind)		Rods				
Wing Fences		Pairs				
Interlocking						
Telegraph and Telephone						
Signals						
Battery Wells						
Paving Kind		Sq. Yds				
Sewers "	Size					
Water Mains "	"					
Fire Hydrants "	No. of Nozzles					
Man Holes	Size					
Catch Basins	"					
Bumping Posts	Style					
Tunnels						
Labor (state character)						
" " "						
Handling Material						
Freight on "						
	TOTALS					
Eng'r and Supt						
	Estimated Gross Cost					
	Less Credits					
	NET ESTIMATED COST					
	The Expense is Chargeable to					
	Maintenance Account					
	Betterment					
	Additions "					

*State kind of Ballast and Quarry or Pit from which it is to be taken if possible.

†Use item, Turnouts Complete, in estimate for track, to be paid for entirely by this Company

Drafting File Reference.................... Letter File Reference....................

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[6] Adopted, Vol. 10, 1909, pp. 865, 866, 869, 873, 874.

Size 8x13 inches. **Form M. W. 2201**

A. B. & C. R. R. CO.

Form for Estimates for **Building / Bridge / Water Service** **Construction**
(Face of Form)

Plan No.____________

Authority No.____________ Estimate No.____________

____________Division

Estimate of Cost of________________________

Prepared________ Date________ By____________ Name____________

Estimate must be itemized under the various headings shown on back of sheet.

Items	Labor		Material						Total	
			Quantity		Unit Cost		Total			
Total										

Cost of Reproducing Abandoned Facilities____________________

Distribution of Cost:
To Maintenance or Operation.____________________
To Betterment.____________________
To Outside Companies or Individuals.____________________

*** Adopted, Vol. 12, 1911.**

Size 8x13 inches.

Form M. W. 2201

Reverse Side of Form for Estimates for Bridges.

Items	Details
1. Additional Land.	Real Estate, Easements.
2 Foundation.	Excavation, Altering Existing Structure, Sheet Piling, Coffer Dam, Piling and Grillage, all expense to prepare for Footing.
3 Substructure	Masonry Footings, Pile Piers, Masonry Piers, Steel Piers.
4. Superstructure.	Steel Erection, Decking, Painting. Masonry Arches, Water Proofing, Reinforcing. Iron, Concrete and other types of Culvert Pipe.
5. Filling and Back Filling and Cleaning	
6 Train Service	
7 Engineering.	
8 Miscellaneous Expense	
Credits	

Size 8x13 inches. **Form M. W. 2201**

Reverse Side of Form for Estimate for Building Construction

Items	Details
1. Preparation of Site.	Grading, Removal of Buildings, etc
2. Foundation	Excavation and Foundation material in place.
3. Body Brick Steel Concrete Framework	All material in place comprising the frame work of the building except items listed separately
4. Platforms and Sidewalks.	All platforms either attached or built in connection with building Give separate estimates for each type, where more than one is to be used.
5. Driveways.	Give separate estimates for each type where more than one type is used.
6. Flooring.	Cost of materials above joists.
7 Plastering.	Including lathing
8. Painting and Decorating.	Interior and Exterior painting and glazing
9. Fire Protection	
10. Lighting.	
11. Hardware.	
12. Heating.	
13. Water Supply.	All expense of Water Supply outside of building proper
14. Plumbing.	
15. Sewerage.	All expense of Sewerage outside of building proper
16. Roofing.	All materials in place above Sheathing.
17. Guttering and Downspouts.	
18. Furniture.	
19. Scales.	
20. Elevators and Conveying Facilities.	
21. Miscellaneous Expense.	
Credits	Covering Salvage and to be itemized as above

Size 8x13 inches. Form M. W. 2201

Reverse Side of Form for Estimate for Water Service Construction.

Items	Details
1. Right-of-Way	Easement, Water Right.
2. Grading	Clearing, Excavation Trenching, Back Filling
3. Fencing	
4. Telephone	Line, Instruments
5. Bridges and Structures	Dams, Wells, Tanks or Stand Pipes, Water Column Softeners, Filter Wind Mill, Track Pan, Power House. Outbuildings. Pumper's Dwelling, Pipe Lines
6. Machinery	Boilers, Engines, Motors, Pumps
7 Transportation	Men and Materials
8. Engineering	
9. Miscellaneous Expense	
Credits	

REMARKS:

Form M. W. 501

A. B. & C. R. R. Co.

MONTHLY TRACK MATERIAL REPORT.

Division ____________ Section No. ____________ For Month Ending ____________ 191___

Column Nos. ——→ 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Description of Material	Unit	On Hand at date of last Report	Received during the Month			Total to Account for	Used and Shipped during the Month					Total Disposed of	On Hand at date of this Report
			By Shipment	Taken Out of Track	From Track Taken up		Repairs		New Tracks		Shipped Away		
							Main Track	Sidings					
Rail — new — 1st. Class ____ lbs. per yard.	Feet												
" " " " ____ " " "	"												
" " 2nd. Class ____ " " "	"												
" " " " ____ " " "	"												
Rail — relaying — ____ " " "	"												
" " ____ " " "	"												
" " ____ " " "	"												
	"												
Scrap Rail — lengths 6ft. and over — lbs. per yard.	"												
" " " " " " " " "	"												
" " " under 6 ft. " " "	"												
Scrap — Frog — Switch and Guard Rails	"												
Scrap — Miscellaneous track	Pounds												
Cross Ties — 1st. Class	Number												
" " " "	"												
" " 2nd. Class	"												
" " " "	"												
Switch Ties — turnout and Crossover — (Fill out space on back.)	Lin'r feet												
Bolts — Track —	Kegs												
" "	"												
R. R. Spikes.	"												
" "	"												
Tie Plates — # Intermediate No.____ Joint No.____	Number												
" " # " "____ "____"____	"												
" " # " "____ "____"____	"												
Nut Locks — diameter of hole	"												
" " " " "	"												
Rail Braces #	"												
" " #	"												
" " #	"												
Tie Plugs —	"												
	"												
Angle Bars — weight ____ drilling ____	Pairs												
" " "____ "____	"												
" " "____ "____	"												
" " "____ "____	"												
" " "____ "____	"												
" " "____ "____	"												
Angle Bars — Offset — from ____ to ____	"												
" " " "____ "____	"												
" " " "____ "____	"												
Angle Bars — Insulated — weight ___# drilling ____	"												
" " " " # "	"												
" " " " # "	"												
" " " " # "	"												
Fibre End Posts — weight —	Number												
" " " "	"												
Frogs (Analysis of balance on hand at end of month) — Kind, No., Weight, New or Old, R.H. or L.H.	"												
	Number												
	"												
	"												
	"												
	"												
Switches (Complete) / Extra Switch Points — Kind, Length, Weight, New or Old	"												
	"												
	"												
	"												
	"												
	"												
	"												
	"												
	"												
Slip Switches — weight ____ No. ____	"												
Guard Rails " ____	"												
" " " ____	"												
" " " ____	"												
Switch Rods — Insulated	"												
" " Plain.	"												
Slide Plates — with braces — weight ___#	"												
" " " " " ___#	"												
" " plain " ___#	"												
" " " " ___#	"												
Switch Stands — Name ____ High or Low ____	"												
" " " " " "	"												
" " " " " "	"												
Switch Latches	"												
Switch Locks —	"												
Frog and Crossing Bolts.	"												
R. R. Crossings — for Crossing ____ weight ___#	"												
Switch Lamps	"												
Signal Lamps	"												
Crossing Plank	Lin'r feet												
Crossing Spikes	Pounds												
Salt	Barrels												
Oil — Headlight	Gallons												
" Signal	"												
" Lubricating	"												
Waste	Pounds												
Pipe — Terra Cotta — size	Lin'r feet												
" " " "	"												
Iron Pipe "	"												
Fence Posts	Number												
Fence Boards	Ft. B. M.												
Wire Fencing —	Rods												
Cattle Guards — Iron ____ Wood ____	Number												
	"												
	"												

Checked and found correct

____
Supervisor of Track.

The above account is correct

____
Section Foreman.

SPECIFICATIONS—Size, 14x17 inches. Ruling, Horizontal—single lines, blue; parallel lines, red; vertical, black or blue.

Form M W. 501

A. B. & C. R. R.

....Division

MONTHLY TRACK MATERIAL REPORT

Section No . . ..

Month of ... 19. .

INSTRUCTIONS.

1. The Section Foreman must keep in a small blank book a daily record of all materials used.

2. He must also keep in the space provided on the back of this blank a daily record of all materials received and shipped.

3. He must close his account on the ......th of each month, and forward the report so as to reach the Supervisor not later than the morning of the . ... th of each month.

4. Column No. 14 must show the material actually on hand on the day the report is made.

5. The Supervisor must check the report, sign it and send it to the Division Engineer so as to reach him on the morning of the ......th.

TO BE FILED IN OFFICE OF DIVISION ENGINEER.

Daily Record of Material "Received by Shipment" and "Shipped Away"

Material Received				Material Shipped Away			
Date	Quantity	Description	From Whom Received	Date	Quantity	Description	To Whom Shipped

Number of Sets of Switch Ties on hand at end of Month

	Turn-outs							Cross-overs			Slips		R.R. Cross-ing	
	No. 4	No. 6	No. 8	No.10	No.12	No.14	No.	No.8	No.10		No.__	No.__		
Sets Ties - New														
" " - Old -														
Total Number														

Number and Length of Extra pieces of Switch Ties on hand at end of Month

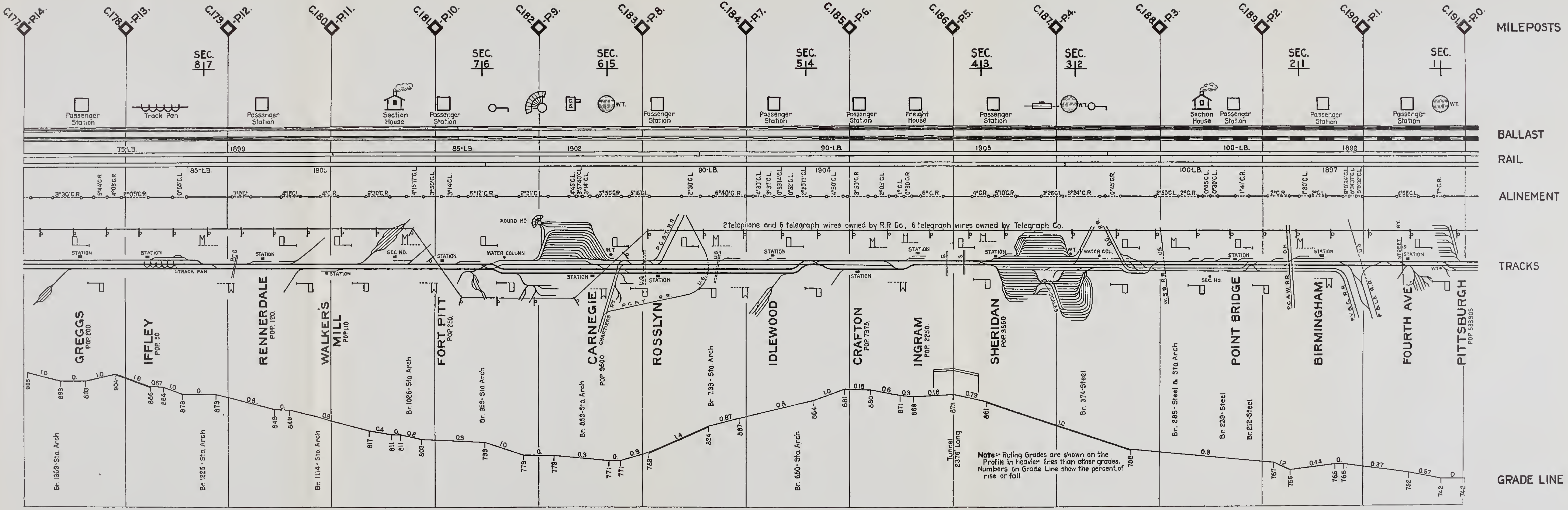
Lengths	8'9"	9'0"	9'3"	9'6"	9'9"	10'0"	10'3"	10'6"	10'9"	11'0"	11'3"	11'6"	11'9"	12'0"	12'3"	12'6"	12'9"	13'0"	13'3"	13'6"
Number Pieces - New																				
" " - Old																				
Lengths	13'9"	14'0"	14'3"	14'6"	14'9"	15'0"	15'3"	15'6"	15'9"	16'0"	16'3"	16'6"	16'9"	17'0"						21'6"
Number Pieces - New																				
" " - Old																				

FORM M. W. 2002.

TRACK CHART.

TRACK CHART

Form M. W. 2002.



sign it and send it to the Division Engineer so as to reach him on the morning of the ......th.

TO BE FILED IN OFFICE OF DIVISION ENGINEER.

Date	Quantity

Sets Ties - Nev
" " - Ol
Total Number

Lengths
Number Pieces-
" "
Lengths
Number Pieces-

FORM M. W. 2202.

SIDE TRACK RECORD.

Size, Approximately 12x24 inches, Tracing Paper.

Form M. W. 2202.

A. B. & C. R. R. Co.—Side Track Record

Side Tracks on ________________ Division ______________ Sub-Division ______________

To be Bound on This Edge.

Mile Post	Location			Township or School District	Name or Number of Track	Connected or Spur	A.F.E.	Contract	Date Completed	Character of Rail (Indicate Age, Weight and Kind)	Total June 30, 19				Changes During Year				Remarks
											Ownership			Total	Ownership			Total	
											Railroad		Private		Railroad		Private		
	Right or Left	Station	State and County				Number	Number			In Corp. Limits	In County			In Corp. Limits	In County			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Amount brought forward.																			
Amount carried forward.																			

so as to reach him on the morning of the
......th.

TO BE FILED IN OFFICE OF DIVISION ENGINEER.

Date	Quantity

Sets Ties - Ne
" " - O
Total Numbe

Lengths
Number Pieces·
" "
Lengths
Number Pieces·
" "

A. B. & C. R. R. Co.

MAIN LINE. REGISTER OF TITLE DEEDS. WAYNE COUNTY, MICHIGAN.

No.	Township.	City.	Sub-Div'n.	Sec.	Town'p	Range.	Block.	Lots.	Description.	Grantor.	Grantee.	Date of Conveyance.	Consideration	Length	Width.	Area.	Recorded.			Kind of Deed	Conditions.
																	B'k	Page.	Date.		
												M. D. Y.							M. D. Y.		
41		Detroit						16, 17, 18	N. E. Cor. 4th and Front	Catherine H. Jones.	M. C. R. R.	Apr. 16, '47.	$2,300	97.48	60	1.34	31	274 275	Sept. 14, '47.	W.	None.
43		“					H	25-26	North of Front	J. Halbert and Wife	“	Mar. 5, '47.	600	86.44	40	.79	31	273 274	“ “ “	W.	“
55		“					K	1-2	S. W. Cor. 4th and Front	Lewis Cass and Wife	“	Sept. 8, '47	19,000			.46	31	278 280	“ “ “	W.	“
40	Springwells	“						Water Lot 2, 3	Bounded E.'ly by Canal Bank, W. Ann Hunt, N. Woodbridge St., S. by channel	J. Mullet and Wife	“	Apr. 16, '47,	5,200	400	169.5	1.55	30	112 113 114	Apr. 20, '47.	W.	
255	“	“							Triangular piece S. E. Cor. 12th and Woodbridge St.	M. C. R. R.	Fort St. Union D.	Dec. 29, '90.	2,900	250	2.25					C.	
8	“	“							Bounded W.'ly by Henry Stanton, E.'ly by Peter Godfrey	Farm'r and Mech Bank J. A. Wells and Wife	M. C. R. R.	Jan. 21, '47.	200	820	140	2.63	29	338-9 340	Jan. 21, '47.	W.	Fences, crossing, gates, etc.
250	“	“	Clarks.					120	S. ½ of E. ½ of E. ½ of P. C. 77	H. Warren and Wife	“	Apr. 30, '02.	1.00			.063	569	292	May 10, '02.	Q. C	
106	Dearborn			29	2s	10 E			W. ½ of N. E. ¼	A. Clay and Wife	“	June 1, '72.	75.00	1350	20	0.62	162	270	June 3, '73.	W.	
12	Nankin			31	2s	9 E			W. ½ of S. E. ¼	C. W. Brink	St. of Mich.	Mar. 3, '41.	1.00	205	100	0.47	20	595-6			R. R. Purposes,
70	“			31	2s	9 E			W. ½ of S. W. ¼	Wm. Bell and Wife	M. C. R. R.	Feb. 25, '48.	1.00	1470	100	3.37	32	563	Mar. 3, '43. Mar. 29, '48.	W. W.	
33	VanBuren			5	3s	8 E			E. ½ of N. W. ¼	B. Cotton and Wife	“	Jan. 8, '47.	1.00	1270	100	2.92	A	504	Jan. 13, '47.	W.	
94	Canton			35	2s	8 E			N. of and adj. Rt. of Way in S. W. ¼	L. Sterling and Wife	“	Jan. 10, '59.	1.00	490	228	2.45	76	360	Jan. 22, '59.	W.	R. R. Purposes.

SPECIFICATIONS FOR FORM M. W. 2000.

Register of Title Deeds.

Form as shown; size of page, 12x28 in.; to be in book form, on heavy white ruled paper; horizontal ruling to be blue; vertical ruling to be red. (Form shown is two-thirds reduction.)

Deeds are filed with the Chief Engineer, the Real Estate Agent, or the Secretary of a railway company, according to individual practice.

The custodian of deeds should keep a Register of Title Deeds, in accordance with the form illustrated.

Deeds should be numbered consecutively, No. 1, 2, 3, etc., in the order of their receipt by the railway company; then forwarded to the proper officer to record on right-of-way maps; then returned by the Chief Engineer to the custodian of deeds with notation thereon that the deed has been properly entered, after which all deeds should be filed in numerical order in a fireproof vault.

Form M. W. 2001.

CONTRACT AND LEASE RECORD.

A. B. & C. R. R.

CONTRACTS AND LEAS

Number	Name of Road	With Whom	Nature of Document		Date			Expires			No. of Canceled Contract	Memoranda

100 Pages

RECEIPTS FOR CONTRACTS AND LEASES REMOVED FROM FILES.

RECEIPTS FOR CONTRACTS AND LEASES REMOVED FROM FILES.

Number	Name of Road	With Whom	Receipt	When taken			When returned				Number	Name of Road	With Whom	Receipt	When taken			When returned		

50 Pages

REFERENCES TO CONTRACTS AND LEASES, SHOWING DATE OF EXPIRATION

REFERENCES TO CONTRACTS AND LEASES, SHOWING DATE OF EXPIRATION

JANUARY																		FEBRUARY																
1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913		1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913

6 Pages

SPECIFICATIONS FOR FORM M. W. 2001.

Contract and Lease Record.

The custodian of leases should keep a Contract and Lease Record Book, containing in the body of the book a full record of the lease in accordance with the form illustrated.

In the back part of the book twelve pages for the twelve months should be ruled into columns for years.

Leases should be numbered and filed in numerical order, by road, branch or division, in a fireproof vault.

Immediately after the receipt of a lease it is entered in the body of the book; the lease number should be entered under the year on the proper month page when it expires.

The names of the lessees should be indexed alphabetically in the front of the book, and each lease should be indexed by the station name.

A few pages in the back of the book should be used for the purpose of keeping a record of the leases removed from the files.

[4] TRACK MAPS.

Note.—Reference is made to the Specifications for Maps and Profiles, as prescribed by the Interstate Commerce Commission in accordance with Section 19A of the Act to Regulate Commerce, dated February 1, 1914, shown in Vol. 15, 1914, pp. 943-950.

(1) Track Maps should show all physical conditions pertaining to the construction and operation of the railway in the limits of the right-of-way, without reference to title or ownership. They should show all main and sidetracks, their alinement, distance between them, and capacity in cars; all buildings upon the right-of-way and adjacent thereto, dimensions and character thereof and location with reference to main or sidetracks; bridges, culverts, water stations, coaling plants, turntables, shop buildings, water mains, conduits, wire lines of all kinds and supports, fences, street car and other railway crossings, and the angle they make with the railway track; sewers, signals of all kinds and physical conditions on the property. Important structures on such maps should be located by chainage numbers and plusses.

(2) They should be corrected whenever any changes are made in any of the features shown thereon, and at stated periods a corrected copy sent to the proper office.

(3) It is recommended that a scale of 100 ft. to the inch be used for such maps except in territories of large industrial development, where varying scales may be used to suit local conditions.

(4) Track Maps should show plainly the meridian, scale, original date and date corrected.

(5) The conventional signs adopted by this Association should be used where it is possible and convenient.

(6) On Track Maps drawn to a scale of 1 in. equals 50 ft. or less, tracks should be represented exclusively by double lines.

(7) On Track Maps drawn to a scale of 1 in. equals 200 ft. or more, tracks should be represented exclusively by single lines.

(8) On Track Maps drawn to a scale of 1 in. equals 100 ft.:

(a) On maps representing preliminary studies and designs of proposed track layouts, tracks should be represented by single lines, except that double lines may be used where considered necessary to show turnout details.

(b) On maps representing completed work, station plats and permanent records, tracks should be represented by double lines.

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[4] Adopted, Vol. 9, 1908, pp. 664, 665, 668, 669, 686-690; Vol. 10, 1909, pp. 835-837, 870, 871; Vol. 16, 1915, pp. 786, 1085.

[7] MONTHLY TRACK MATERIAL REPORT.

The Monthly Track Material Report, Form M. W. 501, containing the necessary information for keeping a proper check on material received and used, is recommended.

[8] PROGRESS PROFILE.

A profile showing complete information respecting the rate of progress of work pertaining to the different features of a railway is necessary, and the standard "Progress Profile," form M. W. 2001, is recommended.

[9] TRACK CHART.

A Track Chart showing complete information respecting the grade, alinement and other physical features of a railway is necessary, and the "Track Chart," form M. W. 2002, is recommended.

[10] AUTHORITY FOR EXPENDITURE.

Construction, addition or betterment work should be authorized in accordance with a reasonable and simple system, involving the preparation of estimates of cost and the formal authorization of the expense by executive officers, and forms M. W. 1107, M. W. 1108 and M. W. 1109 are recommended.

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[7] Adopted, Vol. 6, 1905, pp. 650, 651, 657, 659, 661-663, 668, 672.

[8] Adopted, Vol. 7, 1906, pp. 278, 280, 328, 329.

[9] Adopted, Vol. 8, 1907, pp. 111, 112, 114, 116-120, 132.

[10] Adopted, Vol. 8, 1907, pp. 111, 112, 114, 116-120, 132.

Size 8x13 inches.

Form M. W. 1107.

Estimate No.________________

A. B. & C. R. R. Co.

[11] APPLICATION FOR EXPENDITURE.

________________________DIVISION

Estimate based on Plan No.________ Dated________________________ 19___

LOCATION________________________________

DETAIL OF ESTIMATE	New Work or Additions		Betterments		Renewals or Replacements		Individuals & Companies	
TOTALS								

NOTE: Write in space below date of agreements, name of parties, etc., that are to be billed for items distributed to Individuals and Companies.

The above expenditure is respectfully recommended.

Correct______________ Approved______________ Approved______________

(Title)______________ (Title)______________ (Title)______________

Date______________ Date______________ Date______________

SPECIFICATIONS FOR FORM M. W. 1107.

Size 8x13½ inches; horizontal lines, blue; vertical lines, red; to be printed on medium bond paper (white).

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[11] Adopted, Vol. 9, 1908, pp. 665-667, 669, 674, 675, 693, 694.

(Back of Blank.)

Enter in this space basis used for dividing estimate between betterments and renewals or replacements	Disposition of abandoned building or other structure

INSTRUCTIONS FOR USING THIS BLANK.

(1) When estimate is based upon plans, always refer to numbers and dates of plans.

(2) Observe the following rules in describing work:

(a) When additional buildings or other structures are to be built, begin your description with the word "New."

(b) When a building or other structure is to be built to replace an inferior one, or one of different kind, begin your description with the word "Replacing."

(c) In case of replacement, mention should be made of any variation from the original construction, such as:

Substituting stone for frame building.
Steel for wooden bridge, etc.

(d) When a building or other structure is reconstructed, restoring the original, use the word "Renewing."

(e) Under other conditions use a suitable word, such as:

Strengthening	(Bridges).
Changing	(Yard Tracks).
Altering	(Buildings).
Extending or Widening	(Wharves).
Improvement at	(Consisting of new standard 20x40 foot frame passenger station, renewing 30x50 foot standard frame freight station, altering yard tracks, strengthening bridges, etc.)

(3) CREDITS: When including in the estimate material which is to be used in temporary work, allow (under head of "Credits") an amount to cover estimated value of material to be recovered.

(4) On back of blank, in "Disposition" space, show disposition to be made of the abandoned buildings or other structures.

(5) This form to be submitted in..........by the original officer to the approving officer. (Estimates should be submitted as per special instructions of individual roads.) If estimate is approved, authority for performing work will be given on Form No. 1108.

(6) ESTIMATES should be numbered for identification.

Size 8x10½ inches. Form M. W. 1108.

A. B. & C. R. R. Co.

AUTHORITY FOR EXPENDITURE.

____________________________19__

____

(Title of approving officer.)

..........................Estimate No...... Dated..............191..

Charge to	Charge Approved:
Construction..................................	In all Vouchers, Reports, etc.,
Additions..................................	refer to
Replacements or Renewals................	
Special..................................	AUTHORIZATION No...........
Individuals and Companies..............	
....	
....	....

This authority to be supplemented by Form 1109 at the discretion of the approving officer.

The expenditures under this authority must not exceed the amount authorized. Additional authority must be obtained in case of necessity.

This authority expires at the end of the year in which issued. If work is incomplete at that time, a new authority will be issued for the following year's expenditures.

Size 8x10½ inches. Form M. W. 1109.

A. B. & C. R. R. Co.

APPROPRIATION FOR EXPENDITURE.

______________________________19____

......................Estimate No..........Dated...................191..

Charge to Construction..............................	Charge Approved: ....
Additions..................................	In all Vouchers, Reports, etc.,
Replacements or Renewals..............	refer to
Special..................................	AUTHORIZATION No..........
Individuals and Companies...............	
....	
....	

The expenditures under this authority must not exceed the amount authorized. Additional authority must be obtained in case of necessity.

This authority expires at the end of the year in which issued. If work is incomplete at that time, a new authority will be issued for the following year's expenditures.

SPECIFICATIONS AND INSTRUCTIONS FOR USE OF FORMS

M. W. 1107, 1108 and 1109.

Form M. W. 1107, size 8x13½ inches, to be printed on medium bond paper (white), should be used for submitting estimate of cost of work to the officer who issues the authority (form 1108) for doing the work. This form, when properly filled out, should show:

(1) A reference to the plan number.
(2) A brief and concise description and location of the work covered by the estimate.
(3) Estimate of cost in detail.
(4) Credits, if any, for material to be recovered, etc., such as salvage from false-work, temporary tracks, and in case of a renewal (which renewal is occasioned on account of a fire) the amount of insurance recovered, and anything else that is a proper credit to the job.
(5) Distribution of estimated cost as between New Work, Betterments, Renewals or Replacements and Individuals and Companies.
(6) Estimate will be signed by various officers in accordance with the prevailing organization.
(7) Reproduction cost of any building or other structure which is to be replaced. This information will be required by the officer determining the distribution of the expense.

A set of instructions governing the use of the form has been provided. Special attention is called to those covering the describing of work.

Form M. W. 1108, size 8x10½ inches, to be printed on medium bond paper. (yellow). Yellow paper is recommended so as to make this form distinctive.

This form should be used by the highest executive officer to convey to those interested the fact that the work is authorized and the estimate approved. This form, when properly filled out, should show:

(1) A brief and concise description and location of the work.
(2) Estimated cost, in a lump sum, which lump sum will be the total of the estimate, or estimates, as given on form 1107.
(3) Instructions as to whether form 1109 is to be submitted or not.
(4) A reference to the number, or numbers, of estimates (form 1107) which it covers, and an approved copy of the estimate (form 1107) should be attached to each copy of form 1108, issued for the information of all concerned.
(5) Distribution of expense as between Construction, Additions, Replacements, Special and Individuals and Companies.

This form does not authorize expenditures of money unless it bears a notation that form 1109 will not be required. The actual expenditures of money would be authorized on form 1109, except as above noted.

Form M. W. 1109, size 8x10½ inches, to be printed on medium bond paper (white), should be used by the proper officer to authorize expenditures of money for work authorized by form 1108.

This form, when properly filled out, should show:

(1) A brief and concise description and location of the work to be done.
(2) Total amount of form 1108, of which it is a part.
(3) The Engineer's estimate as covered in form 1108.
(4) A detailed or lump sum amount required for the job.
(5) Distribution of the expense.
(6) Number of the form 1108 against which it applies. A designating letter in addition to the number.
(7) And any other detail required by the company or approving officer.

Note.—For the general outline and description of method of using these blanks see Vol. 8, 1907, pp. 109-111.

Size 8x13 inches.

Form No. 1110

A. B. & C. R. R. Co.

*MONTHLY REPORT OF EXPENDITURES ON AUTHORIZATION.

FOR MONTH OF__________19___

Authority No.________

Amount $________

Location________

Description of Work________

Date Begun________19___ Date Completed________19___

AUTHORITY		Expended During Current Month	Previous Expenditures	Total Expenditures to Date	Est. Expenditures for Ensuing Month	Total Est. Cost of Ensuing Month	Est. Cost of Completed Work	Increase	Decrease	Remarks
Item	Amount									

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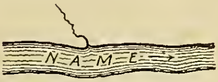
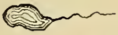
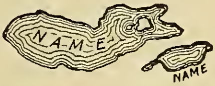
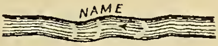
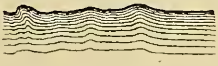
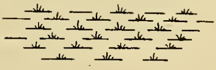
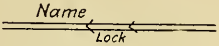
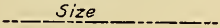
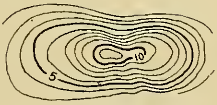
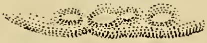
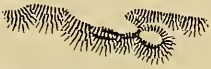
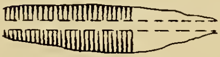
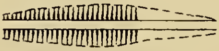
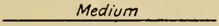
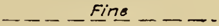
* Adopted, Vol. 9, 1908, pp. 665-667, 673, 691.

[12] CONVENTIONAL SIGN FOR USE ON RAILWAY PROFILES, RIGHT-OF-WAY AND TRACK MAPS.

HYDROGRAPHY.

Stream	
Springs and Sinks	
Lakes and Ponds	
Falls and Rapids	
Water Line	
Marsh	
Canals	
Ditches	

RELIEF.

Contour System	
Sand	
Cliffs	
Cut	
Embankment	
Top of Slope	
Bottom of Slope	

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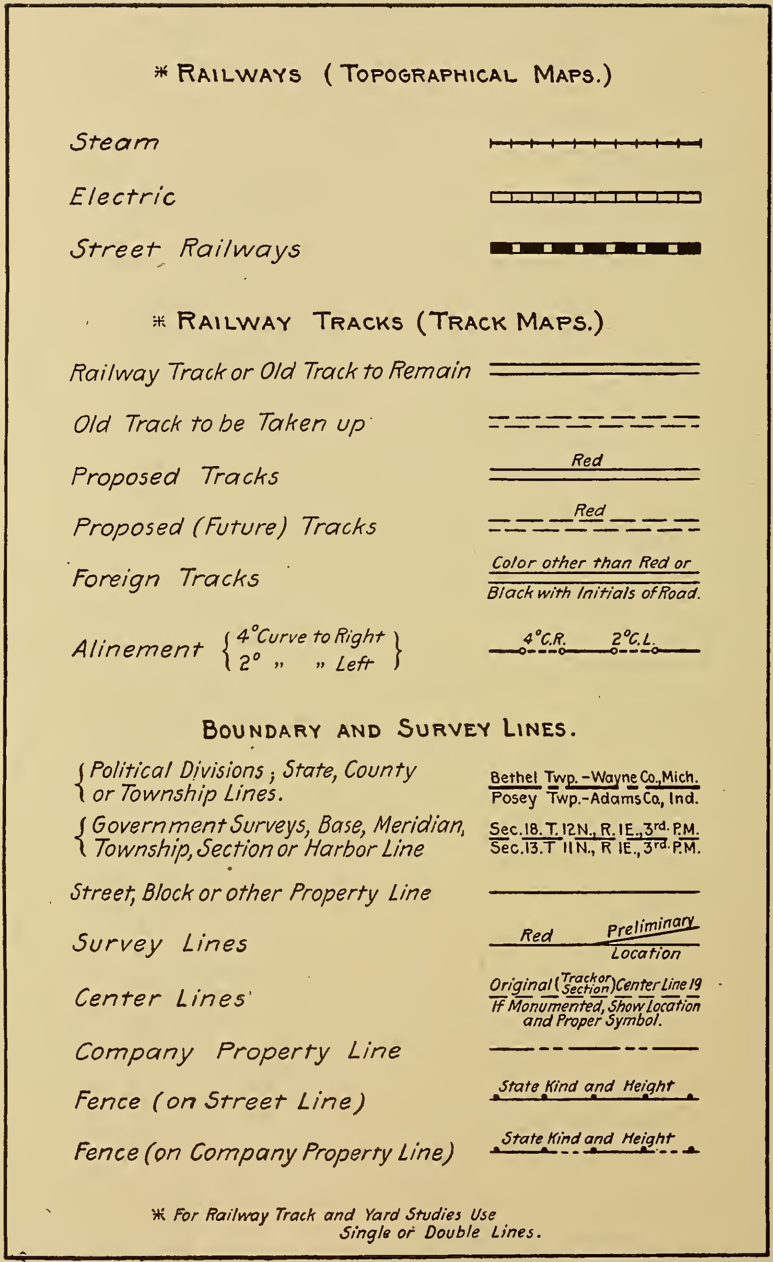
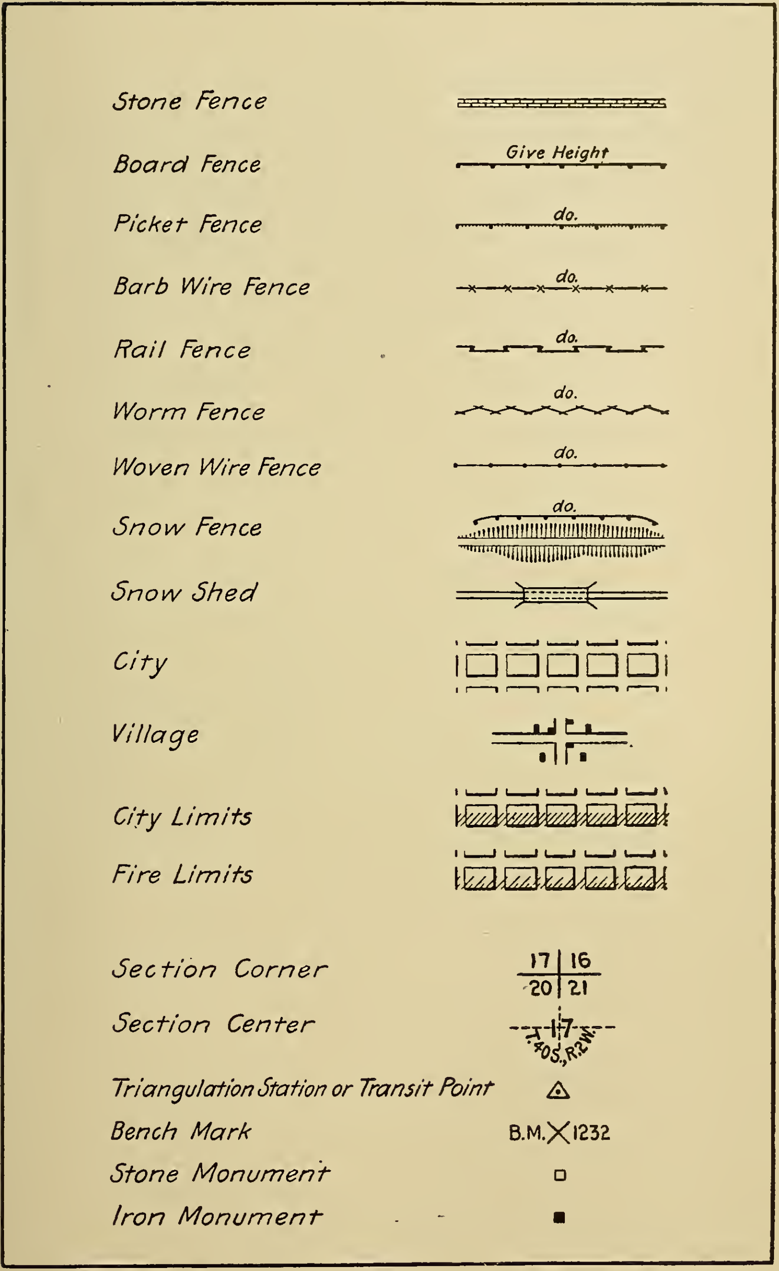
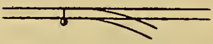
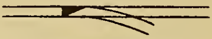
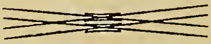
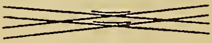
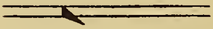
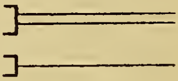
[12] Adopted, Vol. 15, 1914, pp. 930-940, 1160; Vol. 16, 1915, pp. 789, 1086, 1087.

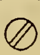
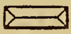
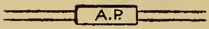
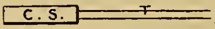
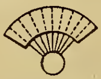
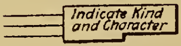

* RAILWAYS (TOPOGRAPHICAL MAPS.)
Steam
Electric
Street Railways
* RAILWAY TRACKS (TRACK MAPS.)
Railway Track or Old Track to Remain
Old Track to be Taken up
Proposed Tracks
Red
Proposed (Future) Tracks
Red
Foreign Tracks
Color other than Red or
Black with Initials of Road.
Alinement { 4° Curve to Right / 2° " " Left }
4°C.R.
2°C.L.
BOUNDARY AND SURVEY LINES.
{ Political Divisions; State, County or Township Lines.
Bethel Twp.-Wayne Co., Mich.
Posey Twp.-Adams Co., Ind.
{ Government Surveys, Base, Meridian, Township, Section or Harbor Line
Sec. 18. T. 12 N., R. 1 E., 3rd. P.M.
Sec. 13. T. 11 N., R. 1 E., 3rd. P.M.
Street, Block or other Property Line
Survey Lines
Red
Preliminary
Location
Center Lines
Original (Track or Section) Center Line 19
If Monumented, Show Location and Proper Symbol.
Company Property Line
Fence (on Street Line)
State Kind and Height
Fence (on Company Property Line)
State Kind and Height
* For Railway Track and Yard Studies Use Single or Double Lines.


Stone Fence
Board Fence
Give Height
Picket Fence
do.
Barb Wire Fence
do.
Rail Fence
do.
Worm Fence
do.
Woven Wire Fence
do.
Snow Fence
do.
Snow Shed
City
Village
City Limits
Fire Limits
Section Corner
17 16
20 21
Section Center
17
T.40S., R.2W.
Triangulation Station or Transit Point
Bench Mark
B.M. 1232
Stone Monument
Iron Monument

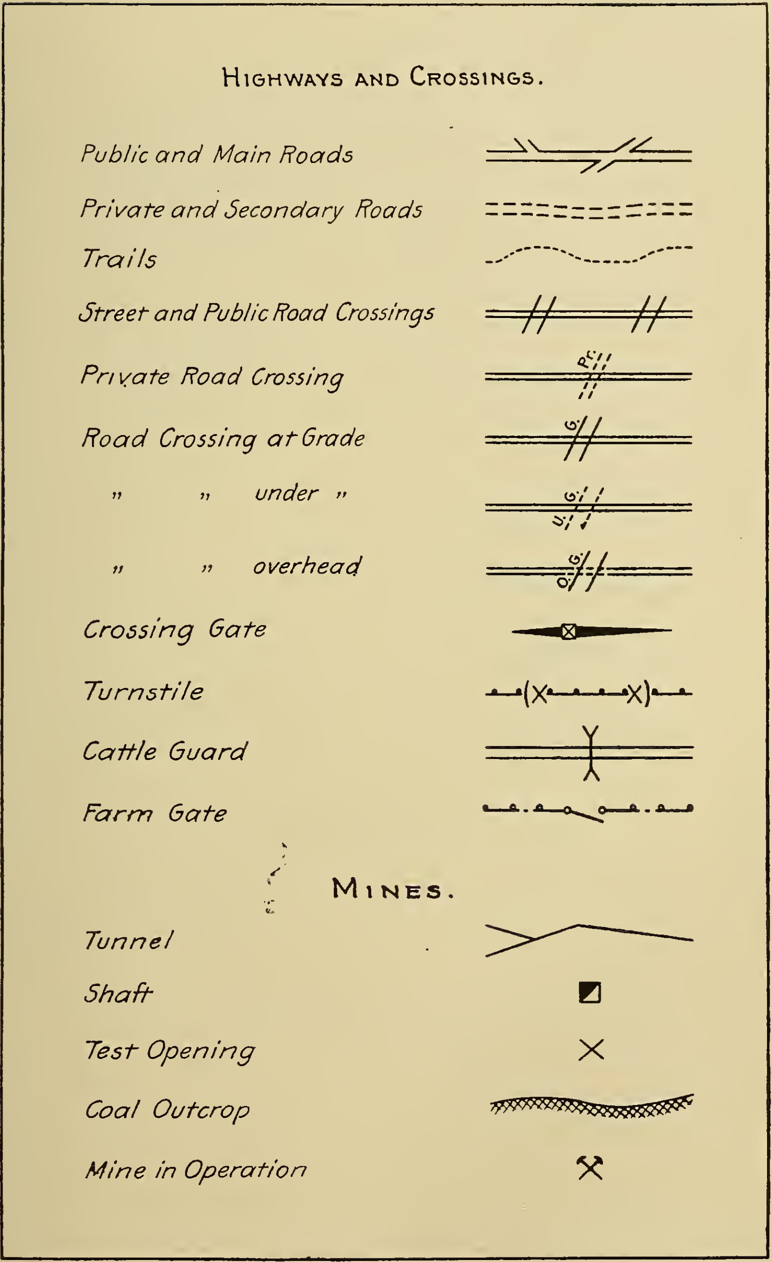
TRACK FIXTURES.

Turnout and Switch-Stand		
Interlocked Switch		
Double Slip Switch		
Single Slip Switch		
Derail		
Bumping Post		

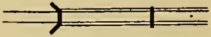
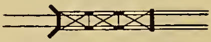
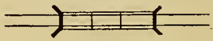
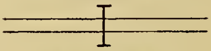
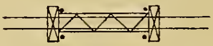
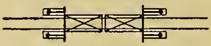
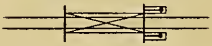
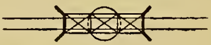
* BUILDINGS.

Stone	S	*Indicate Use and Number of Stories.*
Frame	F	
Brick	B	
Concrete	C	
Corrugated Iron	Cor. I.	
Brick Passenger Station	B.P.	
Electrical Sub-Station	S.S.	
Lightning Arrester House	L.A.	
Platform or Driveway	*Indicate Kind and Character*	
Turntable		
Interlocking Tower		
Ash Pit		
Coal Chute (Mechanical)		
Coal Chute (Trestle)		
Circular Engine House		
Square Engine House		

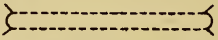
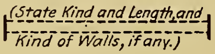
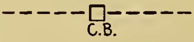
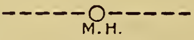
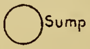
* *Indicate Type and Construction by Combination of Letters, as:*
F.F. = Freight Frame Station, B.F. = Brick Freight Station.


HIGHWAYS AND CROSSINGS.
Public and Main Roads
Private and Secondary Roads
Trails
Street and Public Road Crossings
Private Road Crossing
Road Crossing at Grade
" " under "
" " overhead
Crossing Gate
Turnstile
Cattle Guard
Farm Gate
MINES.
Tunnel
Shaft
Test Opening
Coal Outcrop
Mine in Operation

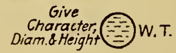
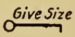
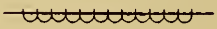
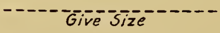
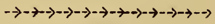
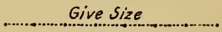
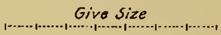
BRIDGES.

Girder	
Truss	
Trestle	
Signal Bridge	
Lift Span	
Bascule, Double Leaf	
Bascule, Single Leaf	
Draw Span	

CULVERTS, SEWERS, ETC.

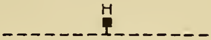
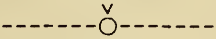
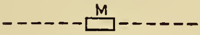
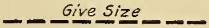
Masonry Arch or Flat Top Culvert	
Pipe or Wood Box Culvert or Drain	
Catch Basin	
Manhole	
Sump	

WATER SUPPLY AND PIPE LINES.

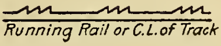
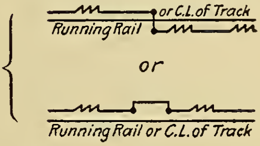
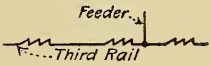
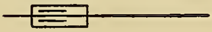
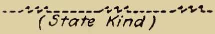
Water Tank	
Water Column	
Track Pan	
Company Water Pipe	
Other Water Pipe	
Steam or Gas	
Compressed Air	

Water Supply and Pipe Lines.

(Continued.)

Fire Hydrant	
Valve	
Riser	
Meter	
Sewer or Drain	

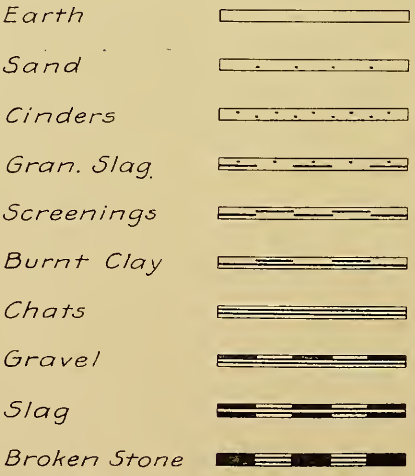
Electrified Lines.

Third Rail	
Jumpers.	 or C.L. of Track Running Rail or Running Rail or C.L. of Track
Feeder	
Switch	
Overhead Rail or Wire	

Rail.

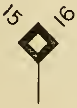
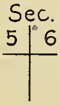
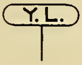
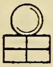
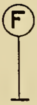
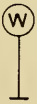
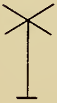
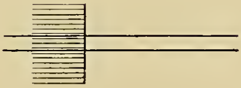
Give Weight in Lbs. per Yard.

Ballast.

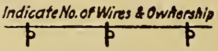
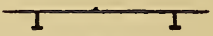
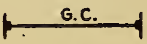
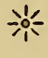
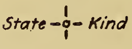
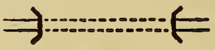
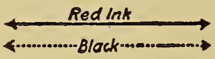
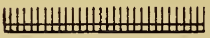
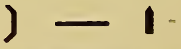
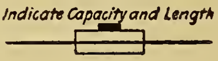
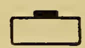
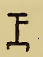
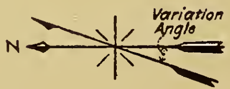
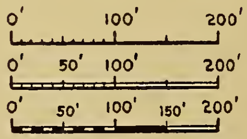
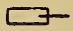


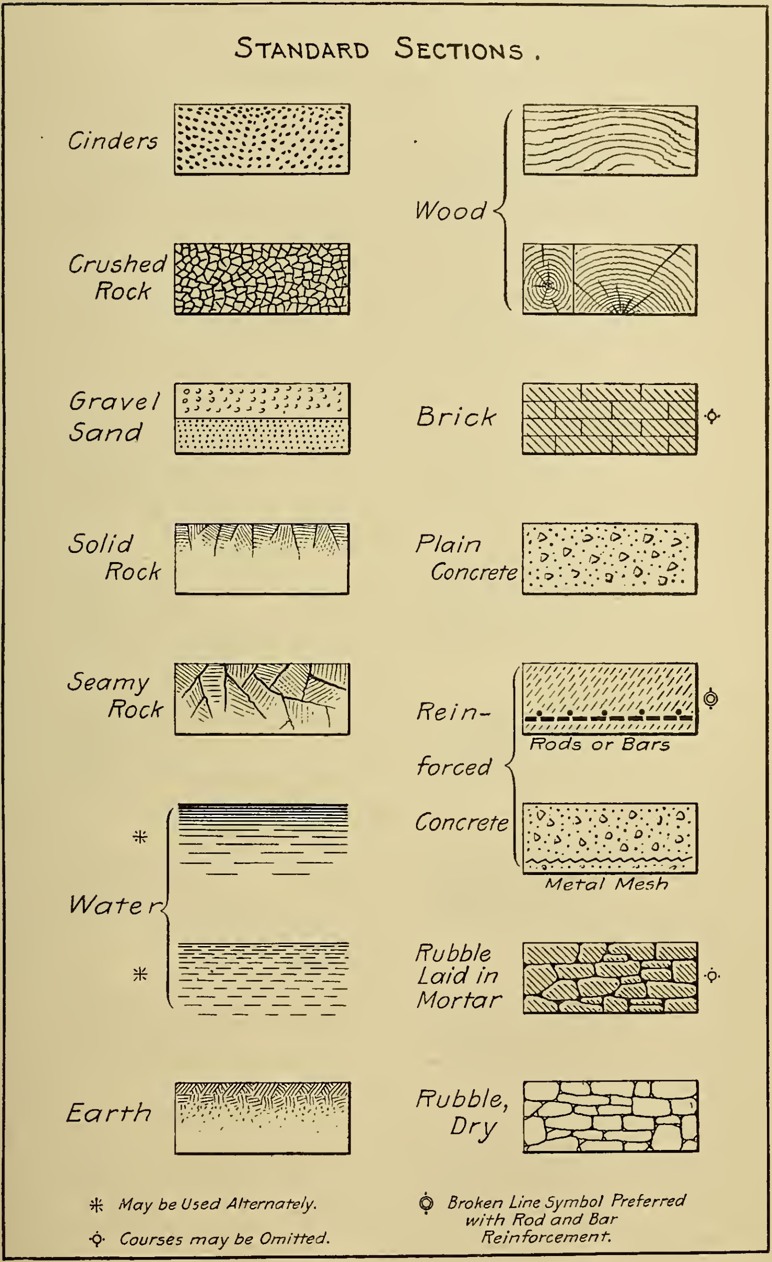
Vol. 16, pp. 789, 1086, 1087.

Signs and Signals.

Mile Post	
Section Post	
Yard Limits.	
Highway Crossing Bell	
Flanger Sign	
Whistle Post	
Crossing Sign	
Tell-Tale	

MISCELLANEOUS.

Pole Wire Lines	
Rail Rest	
Gantry Crane	
Arc Lamp	
Other Lamps	
Railway Tunnel	
Dimension Lines	
Cribbing	
Abutment, Wall and Pier	
Track Scales	
Wagon Scales	
Mail Crane	
True and Magnetic Meridian	
Graphic Scales	 0' 100' 200' 0' 50' 100' 200' 0' 50' 100' 150' 200'
Boom Crane	
Gas Container	

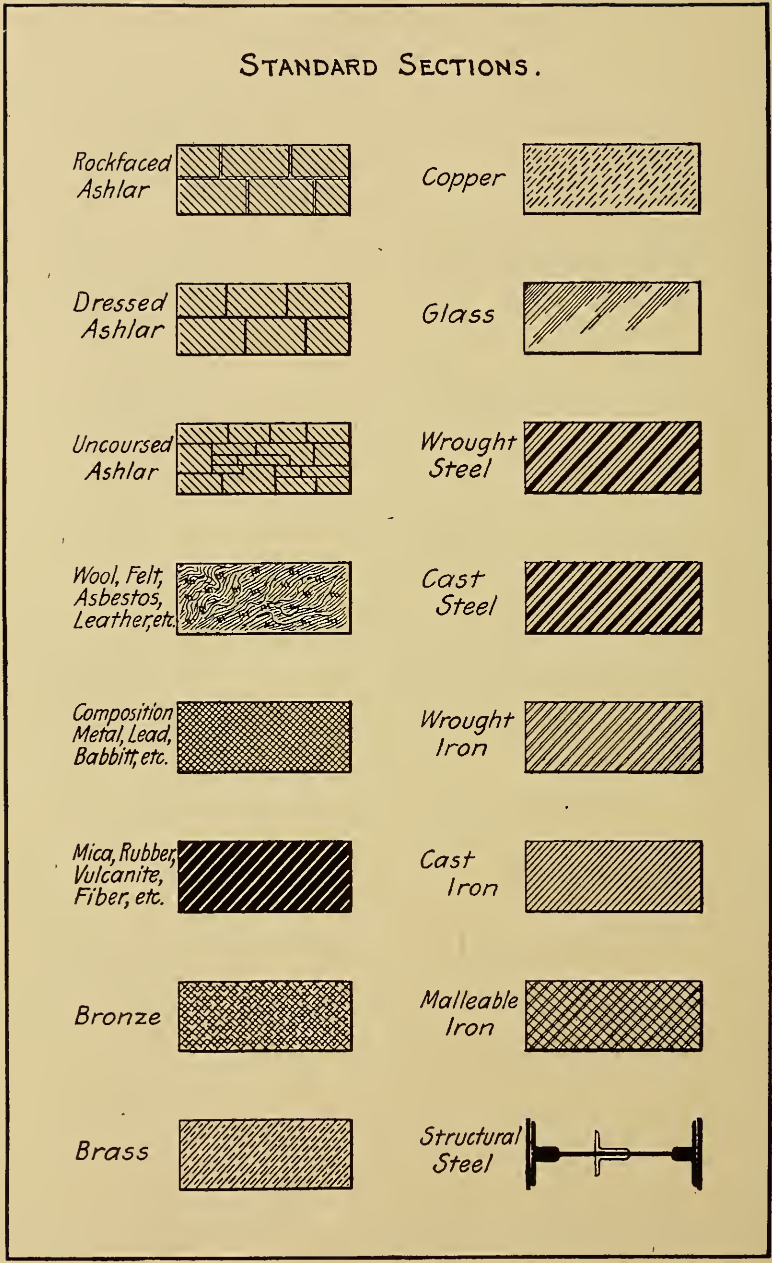


STANDARD SECTIONS.

✳ May be Used Alternately.

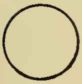
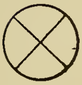
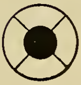
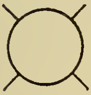
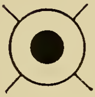
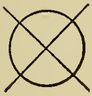
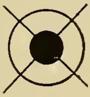
⌖ Courses may be Omitted.

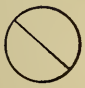
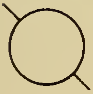
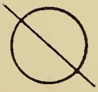
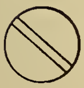
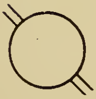
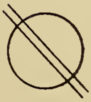
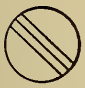
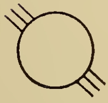
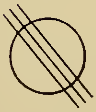
⊚ Broken Line Symbol Preferred with Rod and Bar Reinforcement.



STANDARD SECTIONS.

A—BRIDGE RIVETS.

Shop.	Field.	
		Two Full Heads.
		Countersunk and chipped, far side.
		Countersunk and chipped, near side.
		Countersunk and chipped, both sides.

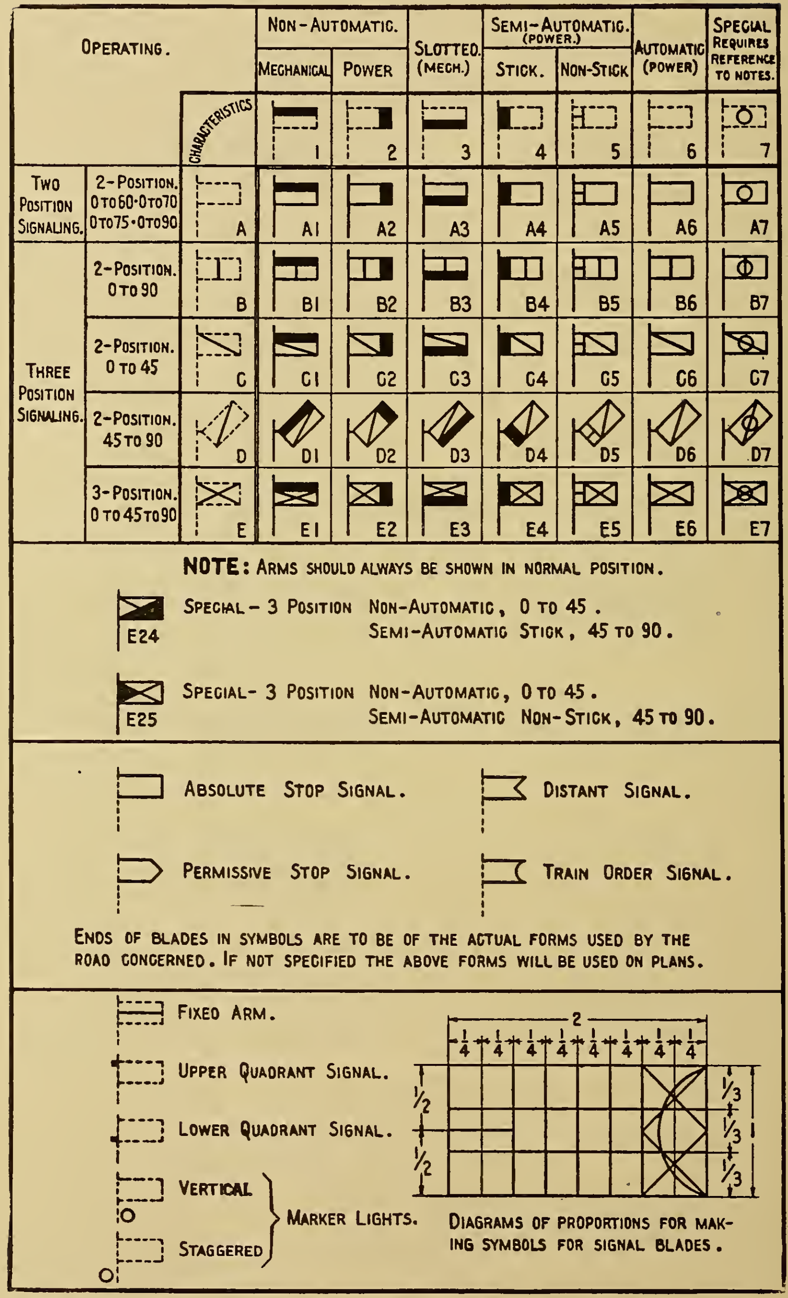
Far Side.	Near Side.	Both Sides.	
			Countersunk and not chipped.
			Flattened to ¼-in. high for ½-in. and ⅝-in. rivets.
			Flattened to ⅜-in. high for ¾-in., ⅞-in. and 1-in. rivets.

B—STRESSES.

+ Tension.

— Compression.

[13] CONVENTIONAL SIGNS FOR SIGNALS AND INTERLOCKING.



NOTE: ARMS SHOULD ALWAYS BE SHOWN IN NORMAL POSITION.

E24 SPECIAL – 3 POSITION NON-AUTOMATIC, 0 TO 45.
SEMI-AUTOMATIC STICK, 45 TO 90.

E25 SPECIAL – 3 POSITION NON-AUTOMATIC, 0 TO 45.
SEMI-AUTOMATIC NON-STICK, 45 TO 90.

ABSOLUTE STOP SIGNAL.

DISTANT SIGNAL.

PERMISSIVE STOP SIGNAL.

TRAIN ORDER SIGNAL.

ENDS OF BLADES IN SYMBOLS ARE TO BE OF THE ACTUAL FORMS USED BY THE ROAD CONCERNED. IF NOT SPECIFIED THE ABOVE FORMS WILL BE USED ON PLANS.

FIXED ARM.

UPPER QUADRANT SIGNAL.

LOWER QUADRANT SIGNAL.

VERTICAL
STAGGERED
} MARKER LIGHTS.

DIAGRAMS OF PROPORTIONS FOR MAKING SYMBOLS FOR SIGNAL BLADES.

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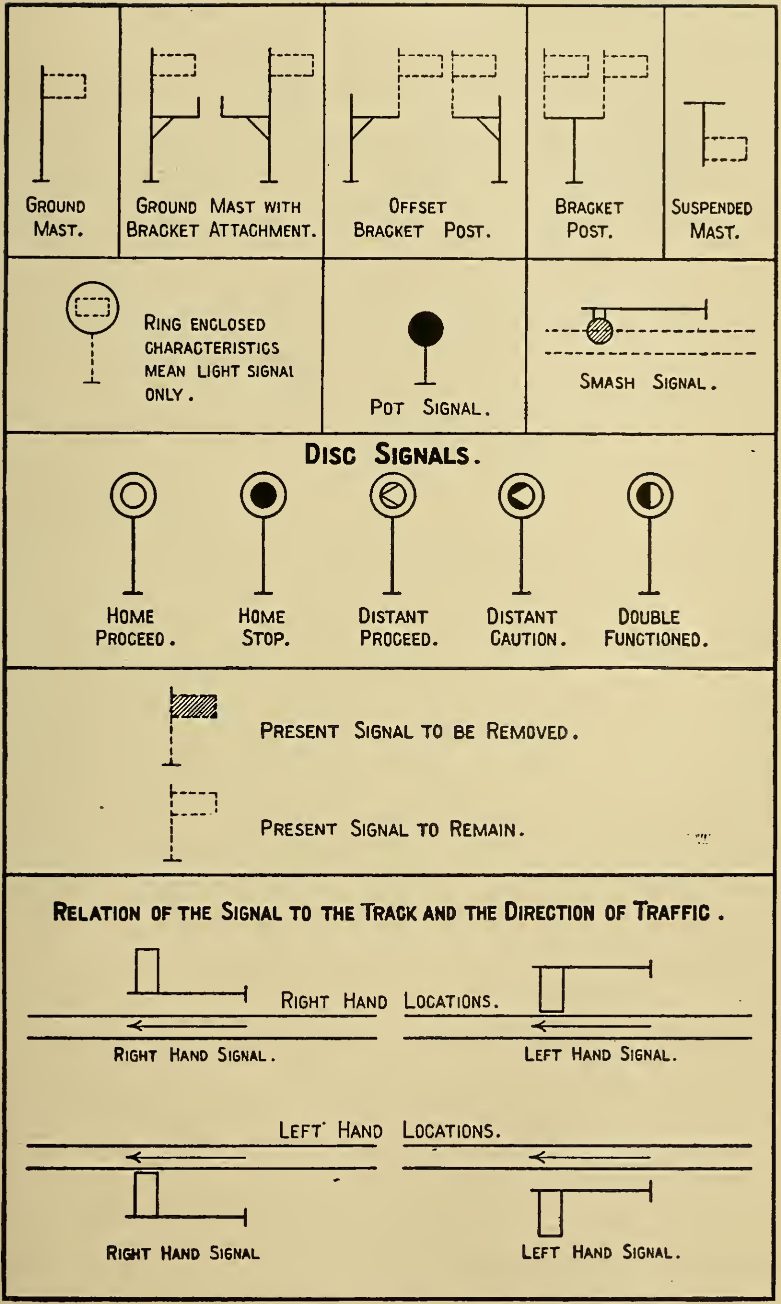
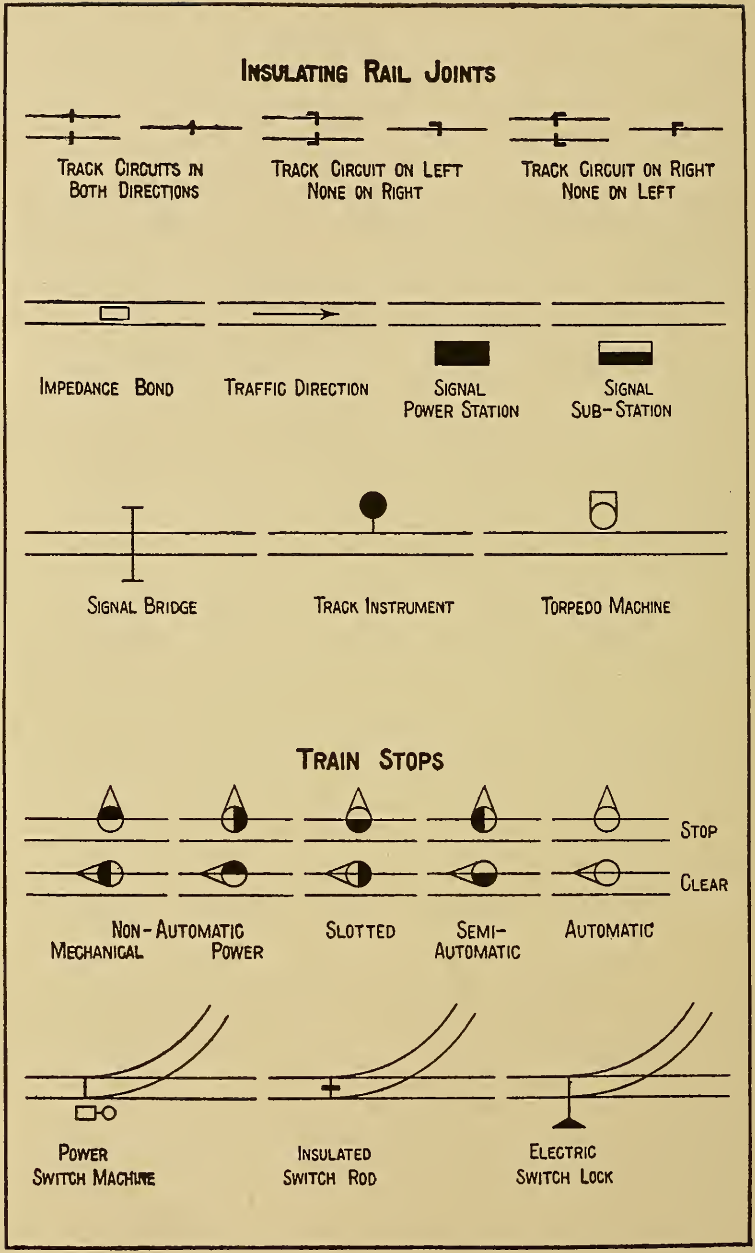
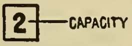
[13] Adopted, Vol. 7, 1906, pp. 515-521, 548; Vol. 15, 1914, pp. 81-92, 1009.


GROUND MAST.
GROUND MAST WITH BRACKET ATTACHMENT.
OFFSET BRACKET POST.
BRACKET POST.
SUSPENDED MAST.
RING ENCLOSED CHARACTERISTICS MEAN LIGHT SIGNAL ONLY.
POT SIGNAL.
SMASH SIGNAL.
DISC SIGNALS.
HOME PROCEED.
HOME STOP.
DISTANT PROCEED.
DISTANT CAUTION.
DOUBLE FUNCTIONED.
PRESENT SIGNAL TO BE REMOVED.
PRESENT SIGNAL TO REMAIN.
RELATION OF THE SIGNAL TO THE TRACK AND THE DIRECTION OF TRAFFIC.
RIGHT HAND LOCATIONS.
RIGHT HAND SIGNAL.
LEFT HAND SIGNAL.
LEFT HAND LOCATIONS.
RIGHT HAND SIGNAL
LEFT HAND SIGNAL.


INSULATING RAIL JOINTS
TRACK CIRCUITS IN BOTH DIRECTIONS
TRACK CIRCUIT ON LEFT NONE ON RIGHT
TRACK CIRCUIT ON RIGHT NONE ON LEFT
IMPEDANCE BOND
TRAFFIC DIRECTION
SIGNAL POWER STATION
SIGNAL SUB-STATION
SIGNAL BRIDGE
TRACK INSTRUMENT
TORPEDO MACHINE
TRAIN STOPS
STOP
CLEAR
NON-AUTOMATIC
MECHANICAL
POWER
SLOTTED
SEMI-AUTOMATIC
AUTOMATIC
POWER SWITCH MACHINE
INSULATED SWITCH ROD
ELECTRIC SWITCH LOCK

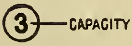


Relay Box.

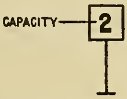
Junction Box.

Terminal Box.

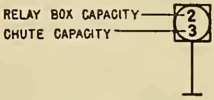
Lightning Arrester Box.



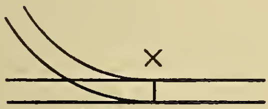
Battery Chute.



Relay Box and Post.

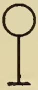


Battery Chute, Relay Box and Post Combined.

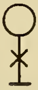


Switch Box Location.

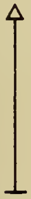
NOTE: Type of indicator to be covered by general note.



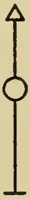
Switch Indicator.



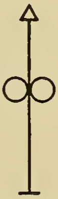
Switch Indicator and Switch Box.



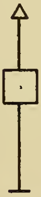
Cable Post Only.



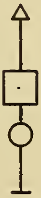
With One Indicator.



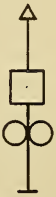
With Two Indicators.



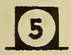
With Relay Box.



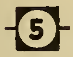
With Relay Box and One Indicator.



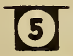
With Relay Box and Two Indicators.



Above Surface.



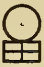
Half Above Surface.



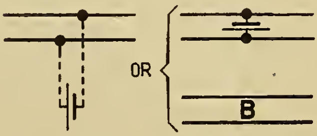
Below Surface.

Battery Shelter.

(Figures indicate capacity)

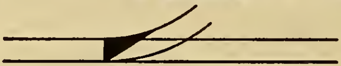


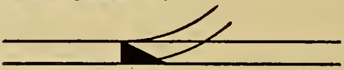
Highway Crossing Bell.

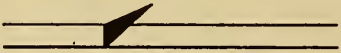


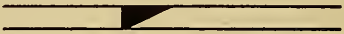
Track Battery.

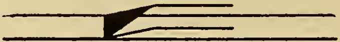
INTERLOCKED SWITCHES AND DERAILS.

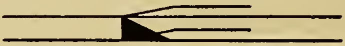

SWITCH—SET FOR TURN-OUT.

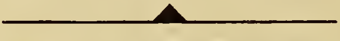

SWITCH—SET FOR STRAIGHT TRACK.

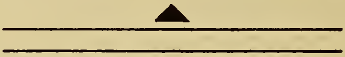

DERAIL—POINT TYPE—DERAILING.


DERAIL—POINT TYPE—NON—DERAILING.


DERAIL—LIFTING RAIL TYPE—DERAILING.

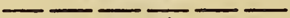

DERAIL—LIFTING RAIL TYPE—NON—DERAILING.

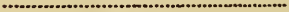

DERAIL—LIFTING BLOCK TYPE—DERAILING.

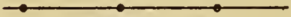

DERAIL—LIFTING BLOCK TYPE—NON—DERAILING.

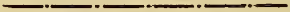
NOTE: NON-INTERLOCKED SWITCHES AND DERAILS TO BE SHOWN SAME AS ABOVE EXCEPT SHADING IN TRIANGLES OMITTED.

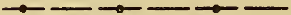
RUNS
OF CONNECTIONS.

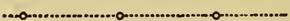

PIPE-WIRE (MECH.).

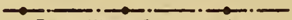

WIRE DUCT.


COMPRESSED AIR.

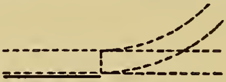

PIPE—WIRE AND DUCT.

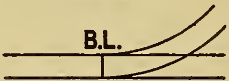

PIPE—WIRE AND AIR.


DUCT AND AIR.


PIPE—WIRE, DUCT AND AIR.

MAN-HOLE.

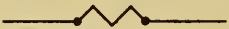

DETECTOR BAR.

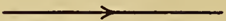


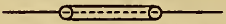
BOLT LOCKED SWITCH.

S.L.M.=SWITCH & LOCK MOVEMENT.

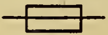
F.P.L.=FACING POINT LOCK.

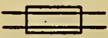

COMPENSATOR.

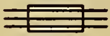

ARROW INDICATES DIRECTION OF MOVEMENT OF PIPE LINE—NORMAL TO REVERSE.


OIL ENCLOSED PIPE LINE.

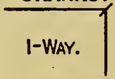
BOLT LOCKS.

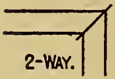

1-WAY.

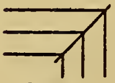

2-WAY.

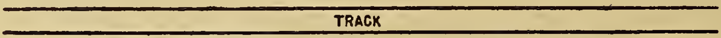

3-WAY.

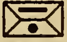
CRANKS.


1-WAY.

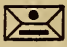

2-WAY.


3-WAY.





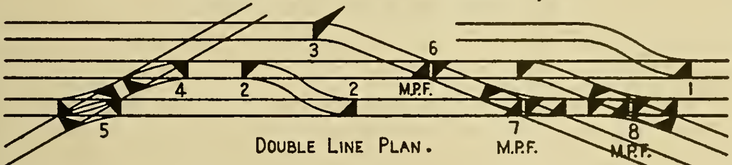
INTERLOCKING OR BLOCK STATION.
SHOWING RELATIVE POSITION OF STATION, OPERATOR AND TRACK.



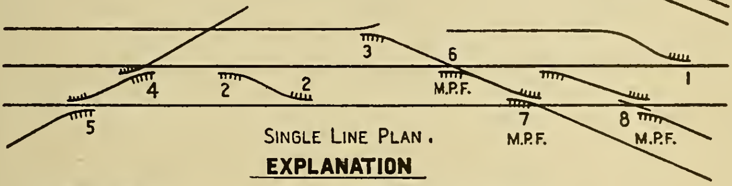
OPERATOR FACING TRACK. OPERATOR WITH BACK TO TRACK.

NOTE: UNLESS OTHERWISE SPECIFIED ON PLAN IT WILL BE ASSUMED THAT WHERE AN INTERLOCKED SIGNAL IS SHOWN CLEAR OR A DERAIL SHOWN IN NON-DERAILING POSITION THE CONTROLLING LEVER IS REVERSED, AND THAT ALL OTHER LEVERS ARE NORMAL.

INTERLOCKED SWITCHES, DERAILS, ETC.



DOUBLE LINE PLAN.

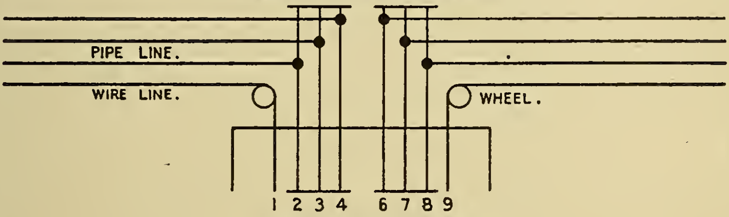


SINGLE LINE PLAN.

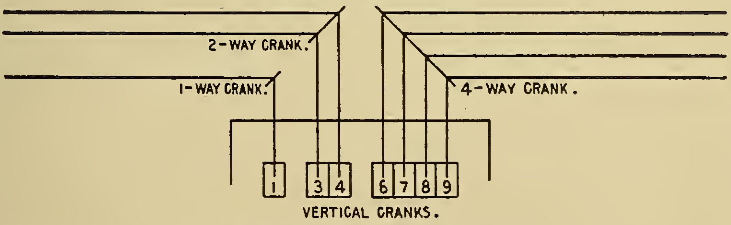
EXPLANATION

1 – SIMPLE TURN-OUT.
2 – SIMPLE CROSS-OVER.
3 – DERAIL–POINT TYPE.
4 – SINGLE SLIP SWITCH.
5 – DOUBLE SLIP SWITCH.
6 – MOVABLE POINT CROSSING FROG. (M.P.F.)
7 – SINGLE SLIP SWITCH WITH M.P.F.
8 – DOUBLE SLIP SWITCH WITH M.P.F.

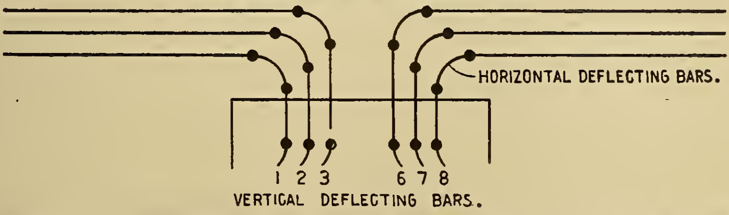
ROCKING SHAFT LEAD-OUT.



CRANK LEAD-OUT.

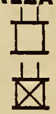


DEFLECTING BAR LEAD-OUT.



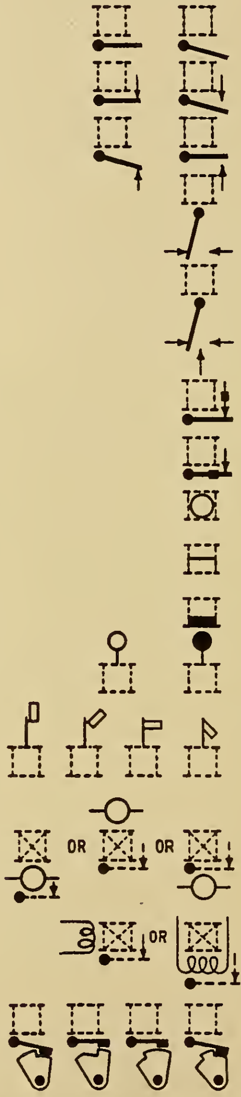
RELAYS, INDICATORS AND LOCKS.

ELEMENTS OF SYMBOLS TO BE COMBINED AS NECESSARY.



D.C. ELECTRO MAGNET.

A.C. ELECTRO MAGNET.



COIL ENERGIZED OR DE-ENERGIZED.

NEUTRAL FRONT CONTACT – CLOSED OR OPEN.

NEUTRAL BACK CONTACT – CLOSED OR OPEN.

POLARIZED ARMATURE – WITH CONTACTS.

3-POSITION ARMATURE – WITH CONTACTS.

HIGH CURRENT CONTACT.

MAGNETIC BLOW-OUT CONTACT.

BELL ATTACHMENT.

DOUBLE WINDING—SPECIFY IF DIFFERENTIAL.

SLOW ACTING.

DISC TYPE INDICATOR. ○ = DISC INVISIBLE. ● = DISC VISIBLE.

SEMAPHORE TYPE INDICATOR. ⚑ = 3-POSITION.

WIRE WOUND ROTOR.

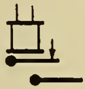
STATIONARY WINDING. ☒ = HIGH VOLTAGE WINDING.

ELECTRIC LOCK – SHOW SEGMENTS FOR LEVER IN NORMAL POSITION.

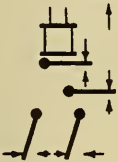
(SEE NEXT PAGE FOR EXAMPLES OF COMBINATIONS.)

Relays, Indicators and Locks.

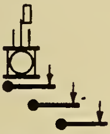
Examples of Combinations.



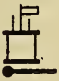
D.C. RELAY – Neutral – Energized –
One Independent Front Contact Closed –
One Independent Back Contact Open.



D.C. RELAY – Polarized – Energized –
Two Combination Front and Back Neutral Contacts –
Two Polarized Contacts Closed –
Two Polarized Contacts Open.

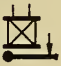


D.C. INDICATOR – Semaphore Type – Energized –
Three Front Contacts Closed –
Bell Attachment.

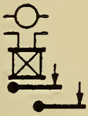


D.C. INDICATOR – Semaphore Type – Arm Horizontal –
Energized – Without Contacts.

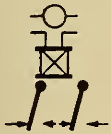
NOTE: Indicators (or repeaters) without contacts should be shown with armatures to indicate whether energized or de-energized.



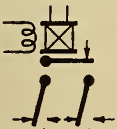
A.C. RELAY – One Energizing Circuit Type (Single Phase)
Energized – One Front Contact.



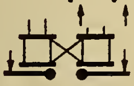
A.C. RELAY – Two Energizing Circuit Type – Energized –
Wire Wound Rotor –
Two Neutral Front Contacts.



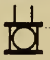
A.C. RELAY – Two Energizing Circuit Type – Energized –
Wire Wound Rotor –
Two Polarized Contacts.



A.C. RELAY – Two Energizing Circuit Type – Energized –
Stationary Windings –
One Neutral Front Contact –
Two 3-Position Contacts.



D.C. INTERLOCKED RELAY.



D.C. ELECTRIC BELL.

DESIGNATE RESISTANCE IN OHMS OF ALL D.C. RELAYS, INDICATORS AND LOCKS.

CIRCUIT CONTROLLERS OPERATED BY LEVERS.

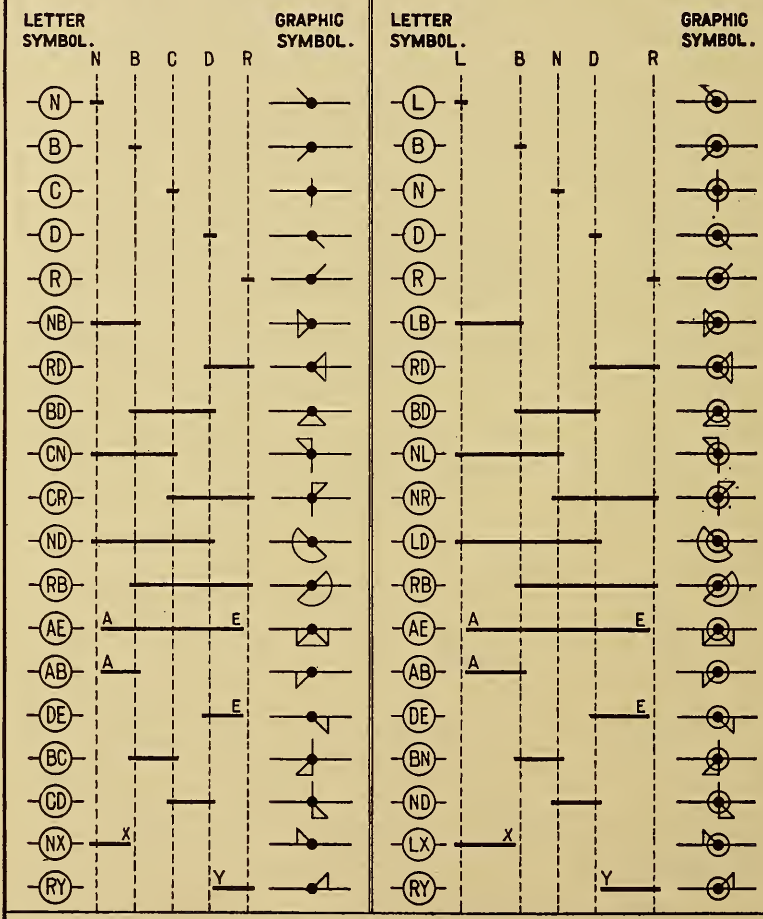
USE EITHER LETTER SYSTEM OR GRAPHIC SYSTEM.

LEVERS WITH EXTREME END POSITION AS NORMAL.

N-FULL NORMAL POSITION OF LEVER
B-NORMAL INDICATION POSITION.
C-CENTRAL POSITION.
D-REVERSE INDICATION POSITION.
R-FULL REVERSE POSITION.

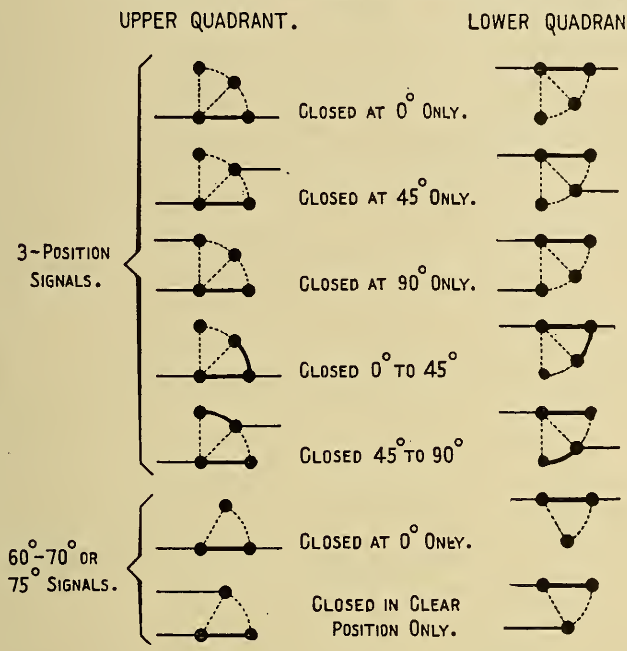
LEVERS WITH MIDDLE POSITION AS NORMAL.

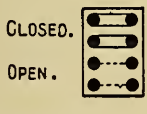
N-NORMAL POSITION.
L-FULL REVERSE POSITION TO THE LEFT.
B-INDICATION POSITION TO THE LEFT.
D-INDICATION POSITION TO THE RIGHT.
R-FULL REVERSE POSITION TO THE RIGHT.



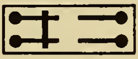
NOTE: HEAVY HORIZONTAL LINES INDICATE PORTION OF CYCLE OF LEVER THROUGH WHICH CIRCUIT IS CLOSED.

Circuit Controllers Operated by Signals.

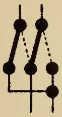




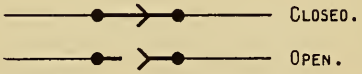
Switch Circuit Controller.



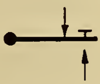
Circuit Controller Operated by Locking Mechanism of a Switch Movement.



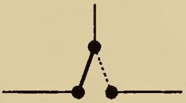
Pole Changing Circuit Controller.



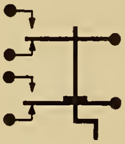
Bridge Circuit Controller.



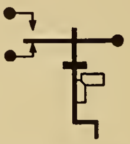
Spring Hand Key or Push Button.



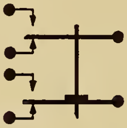
Circuit Switch.



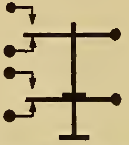
MANUAL TIME RELEASE.
(ELECTRIC)



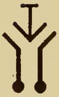
MANUAL TIME RELEASE.
(ELECTRO-MECHAN'L.)



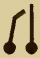
AUTOMATIC TIME RELEASE.
(ELECTRIC)



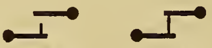
EMERGENCY RELEASE.
(ELECTRIC)



FLOOR PUSH.



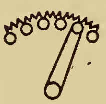
LATCH CONTACT.



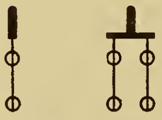
OPEN. CLOSED.

TRACK INSTRUMENT CONTACT.

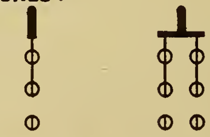
KNIFE SWITCHES.



RHEOSTAT.

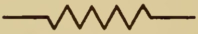


SINGLE POLE. DOUBLE POLE.
SINGLE THROW.

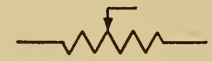


SINGLE POLE. DOUBLE POLE.
DOUBLE THROW.

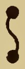
QUICK ACTING CIRCUIT CONTROLLERS MAY BE DISTINGUISHED BY THE LETTER "Q"



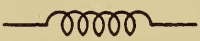
FIXED RESISTANCE.



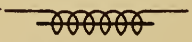
VARIABLE RESISTANCE.



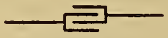
FUSE.



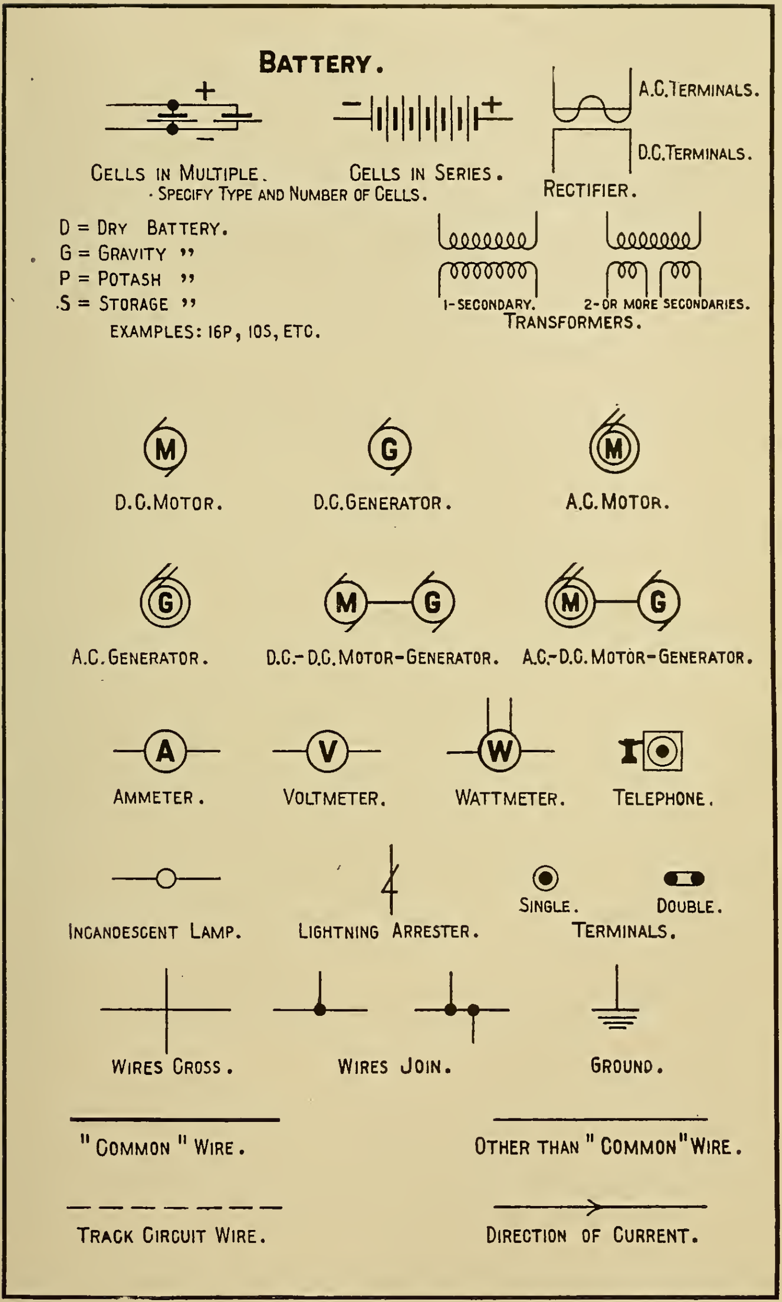
IMPEDANCE WITHOUT
IRON CORE.



IMPEDANCE WITH
IRON CORE



CONDENSER.


BATTERY.
+
−
−
+
CELLS IN MULTIPLE.
CELLS IN SERIES.
· SPECIFY TYPE AND NUMBER OF CELLS.
A.C. TERMINALS.
D.C. TERMINALS.
RECTIFIER.
D = DRY BATTERY.
G = GRAVITY ”
P = POTASH ”
S = STORAGE ”
EXAMPLES: 16P, 10S, ETC.
1-SECONDARY.
2-OR MORE SECONDARIES.
TRANSFORMERS.
M
D.C. MOTOR.
G
D.C. GENERATOR.
M
A.C. MOTOR.
G
A.C. GENERATOR.
M
G
D.C.-D.C. MOTOR-GENERATOR.
M
G
A.C.-D.C. MOTOR-GENERATOR.
A
AMMETER.
V
VOLTMETER.
W
WATTMETER.
TELEPHONE.
INCANDESCENT LAMP.
LIGHTNING ARRESTER.
SINGLE.
DOUBLE.
TERMINALS.
WIRES CROSS.
WIRES JOIN.
GROUND.
" COMMON " WIRE.
OTHER THAN " COMMON " WIRE.
TRACK CIRCUIT WIRE.
DIRECTION OF CURRENT.

[14] REASONS FOR MAINTAINING A STOREHOUSE.

The following statement embodies the general principles governing the economical management of a railway storehouse:

The object of a storehouse is to provide material and tools when required so that the cost of work may be a minimum, bearing in mind the factors of delay to work and labor, also interest on investment in stock.

The following essential elements enter into the problem:

Standardization.

The standardization of materials and instructions in regard to their use will reduce to a minimum the number of items of material of the various classes which should be carried in stock. The amount of each item which should be carried in stock will depend upon the rate of consumption, time required for the purchase and delivery of material, and also upon local conditions.

Classification of Material.

This is necessary so as to reduce to a minimum the cost and time of handling. An approved classification should be followed in making requisitions.

Stock Account.

An account should be kept of stock showing at all times a record of receipts, disbursements and amount on hand. Stock should be replenished when the amount of any item has been reduced to a fixed minimum. Inventories should be made at stated periods. A proper stock account furnishes a check on excessive supply and obsolete material.

Distribution.

When material is shipped, notice should be sent to consignee showing partial or complete filling of requisition, and if partial, when final shipments may be expected.

Organization.

The storekeeper's place in the general organizattion should be so fixed and adjusted that the measure of his efficiency is, primarily, the promptness and accuracy with which he fills requisitions, and, secondly, his ability to hold down the stock investment to the lowest amount consistent with the first requirement.

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[14] Adopted, Vol. 13, 1912, pp. 506-507, 996-997.

COMMITTEE XII.

RULES AND ORGANIZATION.

[1] GENERAL RULES FOR THE GOVERNMENT OF EMPLOYÉS OF THE MAINTENANCE OF WAY DEPARTMENT.

GENERAL NOTICE.

(1) To enter or remain in the service is an assurance of willingness to obey the rules.

(2) The service demands the faithful, intelligent and courteous discharge of duty.

(3) Obedience to the rules is essential to the safety of passengers and employés, and to the protection of property.

(4) Employés must exercise care and watchfulness to prevent injury to themselves, other employés and the public, and to prevent damage to property. In case of doubt they must take the safe course. They must know that all tools and appliances are in safe condition before using. They must move away from tracks upon approach and during passage of trains, and, so far as practicable, prevent the public from walking on tracks or otherwise trespassing on the right-of-way. They must familiarize themselves with the safety regulations of the Company.

(5) Employés must do all in their power to prevent accidents, even though in so doing they occasionally perform the duties of others.

(6) Co-operation is required between all employés whose work or duties may be jointly affected.

(7) Anything that interferes with the safe passage of trains at full speed is an obstruction.

(8) Employés in accepting employment assume its risks.

(9) To obtain promotion, capacity must be shown for greater responsibility.

(10) Employés must not absent themselves from duty, exchange duties with others or engage substitutes.

(11) Employés must conduct themselves properly at all times. They will be courteous to fellow-employés and patrons of the road.

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[1] Adopted, Vol. 7, 1906, pp. 20, 21, 26; Vol. 8, 1907, pp. 24-39; Vol. 9, 1908, pp. 29, 30, 31-38; Vol. 10, 1909, pp. 51-55, 56-69; Vol. 12, Part, 1, 1911; Vol. 15, 1914, pp. 66, 67, 1003-1005.

(12) The use of intoxicants by employés while on duty is prohibited. Their use, or the frequenting of places where they are sold, is sufficient cause for dismissal.

(13) Employés subject to emergency call shall notify their immediate superior officer and the Division Superintendent of any change in address, whether temporary or permanent.

ORGANIZATION.

(1) The Maintenance of Way Department on each division is in charge of the....................(Title)....................who will report to and receive instructions from the..............(Title)..................

(2) The work of the Department will be subdivided under the following heads:

Track Supervisors.
Supervisors of Structures.
Signal Supervisors.

RULES GOVERNING TRACK SUPERVISORS.

(1) Track Supervisors shall report to and receive instructions from the.........................(Title)...................................

(2) They shall be responsible for the safe condition and proper maintenance of track, roadway, right-of-way, station grounds and driveways, and must inform themselves of the condition of structures. They must make temporary repairs of such defects as may endanger or delay the movement of trains, and promptly report defective conditions to the
...............................(Title)...............................

(3) They must make frequent inspections of track, roadway, right-of-way, station grounds and driveways, and have necessary repairs made as promptly as conditions require.

(4) They shall, as necessary, employ men for carrying out the duties for which they are responsible.

(5) They must know that foremen are familiar with the operating rules in regard to train signals and flagging, and that they fully understand and comply with them.

(6) They must, in case of obstruction or damage to track or roadbed, proceed to the place with the forces at their command and do all in their power to promptly clear and repair the track.

(7) They shall investigate and report on Form No.......accidents which may be attributable to defects in, or result in damage to, track, roadbed or structures.

(8) They shall conform to the prescribed standards, plans and specifications in the execution of work under their charge.

(9) They must know that foremen are supplied with tools and materials necessary for the efficient performance of their duties, and see that these are properly used and cared for.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They shall keep themselves informed in regard to all work performed in their districts by contractors, or others who do not come under their charge, and see that nothing is done by them that will interfere with the safety of track or the movement of trains.

(12) They shall have immediate supervision of work train service for the maintenance of track and employ such service only when authorized by the ....(Title)..............................

(13) They must know that foremen are provided with the rules, circulars, forms, special instructions and safety regulations pertaining to their duties, and that they fully understand and comply with them.

(14) They shall see that the vicinity of all bridges and trestles is clear of all combustible matter, and that bridge seats, tops of piers and other readily accessible portions of bridges and trestles are clear of cinders and dirt and that water barrels are full of water.

(15) They shall see that waterways and the approaches and outlets thereto are free from obstructions.

(16) They shall see that no encroachment upon, or occupancy of any portion of the Company's buildings, right-of-way or station grounds is permitted, except by proper authority.

(17) Any action proposed by State, County, Township, Municipal or other authority, which will in any way affect the Company, shall be reported immediately to the ....(Title)........................

RULES GOVERNING TRACK FOREMEN.

(1) Track Foremen shall report to and receive instructions from the..................................(Title)....................................

(2) Unless otherwise directed, they shall be responsible for the proper inspection and safe condition of the track and roadway under

their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

(3) They must go over their sections, or send a reliable man, with suitable tools, at least once a day to make a thorough inspection, to see that the track, highway crossings, signals, culverts, bridges, fences, telegraph lines, etc., are in safe condition.

(4) They shall employ men as the..............(Title).............. directs. They must treat employés with consideration and see that they properly perform their duties. They must discharge men who are incompetent or neglect their duties, but in no case shall they discharge men without cause. They must keep the required records of the time of their men and of the material used.

(5) They must each have a copy of the current timetable, and be thoroughly familiar with the rules and regulations therein, and with the time of trains over their sections. They must carefully observe signals displayed by all trains, and assure themselves before obstructing track that all trains and sections due have passed. No notice will be given of extra trains, and employés must protect themselves as prescribed by the rules. Foremen must provide themselves with reliable watches, and, when possible, verify time daily with a standard clock or with the watches of other employés who are required to have the standard time.

(6) If, in the judgment of the Track Foreman, the track or any bridge or culvert is not safe, he must at once put out the proper signals to warn approaching trains, notify the proper officers of its condition, and do all in his power to make necessary repairs.

(7) Track Foremen must, in case of accident, promptly render all assistance in their power, whether the accident occurs on their own or adjacent sections. They shall investigate and report on Form No........ all accidents occurring on their sections, which may be attributable to, or result in damage to, track, roadbed or structures.

(8) They shall conform to the prescribed standards, plans and specifications in the execution of work under their charge.

(9) They shall be responsible for the proper care and use of tools and materials necessary for the efficient performance of their duties, and shall make requisitions to the..................(Title).................... from time to time as additional supply becomes necessary.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They shall keep themselves informed in regard to all work performed on their sections by contractors, or others who do not come under their charge, and see that nothing is done by them that will interfere with the safety of the track or the movement of trains.

(12) They must limit the use of handcars to the service of the Company, and must not, except by proper authority, permit anyone except employés of the Company, engaged in the performance of duty, to ride thereon. They must not permit, except by proper authority, the running of hand or velocipede cars belonging to private parties over the tracks of the Company.

(13) During heavy storms, whether by day or night, whereby the track or any portion of the Company's property becomes liable to damage, foremen and trackmen must be on duty; and at such times they must go over their sections to make sure that the track is safe, taking danger signals with them.

(14) They must keep the vicinity of all buildings, bridges and trestles cleared of all combustible matter, such as chips, bark, dry grass, etc. They must keep bridge seats, tops of piers, and all other readily accessible portions of bridges and trestles cleaned of cinders and dirt. Where water barrels are furnished, they must keep them filled with water

(15) They must keep a careful lookout for fires along the track, and prevent, if possible, the destruction of fences, wood or other material, and the spread of fires into adjoining fields. They must not permit fires to be started unless they have sufficient force to keep them under control.

(16) They must use constant care to see that waterways and the approaches and outlets thereto are kept free from brush, driftwood and other obstructions.

(17) They must not permit encroachment upon, or occupancy of, any portion of the Company's buildings, right-of-way, or station grounds, except by proper authority.

(18) Any action proposed by State, County, Township, Municipal or other authority, which will in any way affect the Company, shall be reported immediately to the ....(Title)......................

(19) They must thoroughly understand the rules, circulars, forms, special instructions and safety regulations pertaining to their duties, and see that they are complied with.

(20) They must keep all interlocking pipe lines and trunking free from grass and weeds, and all switches, frogs and movable parts of interlocking plants free from snow, ice and other obstructions. They

must give special attention to drainage through interlocking plants and where track circuits are used.

RULES GOVERNING SUPERVISORS OF STRUCTURES.

(1) Supervisors of Structures shall report to and receive instructions from the..................(Title)..................

(2) They shall be responsible for the safe condition and proper maintenance of structures. They must make temporary repairs of such defects as may endanger or delay the movement of trains, and promptly report defective conditions to the..................(Title)..................

(3) They must make frequent inspections of structures and have necessary repairs made as promptly as conditions require.

(4) They shall, as necessary, employ men for carrying out the duties for which they are responsible.

(5) They must know that foremen are familiar with the operating rules in regard to train signals and flagging, and that they fully understand and comply with them.

(6) They must, in case of damage to structures, promptly assemble forces, tools and materials and make necessary repairs.

(7) They shall investigate damage to structures resulting from train accidents or other causes and make prompt report to the .....(Title).....

(8) They shall conform to the prescribed standards, plans and specifications in the execution of work under their charge.

(9) They must know that foremen are supplied with tools and materials necessary for the efficient performance of their duties, and see that these are properly used and cared for.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They shall keep themselves informed in regard to all work performed on bridges and structures in their districts by contractors, or others who do not come under their charge, see that nothing is done by them that will interfere with the safety of structures, and report promptly to the..................(Title)..................if the work is not done in accordance with the prescribed standards.

(12) They shall have immediate supervision of work-train service for the maintenance of structures, and employ such service only when authorized by the........................(Title)........................

(13) They must know that foremen are provided with the rules, circulars, forms, special instructions and safety regulations pertaining to their duties, and that they fully understand and comply with them.

(14) They shall see that water barrel rests at all timber bridges and trestles are in repair and supplied with barrels and buckets, and that station and other structures are equipped with the necessary water barrels, buckets and other appliances.

(15) They shall, in period of flood, observe and record the flow of water of the various streams passing under the track, and report to the proper officer any case in which the opening seems insufficient.

RULES GOVERNING BRIDGE AND BUILDING FOREMEN.

(1) Bridge and Building Foremen shall report to and receive instructions from the ....(Title)..............................

(2) They shall be responsible for the proper inspection and safe condition of the structures under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

(3) They must make such inspections of the structures in their district as the ....(Title).................... may direct, and report their condition on Form No. ......

(4) They shall employ men as the ....(Title)............... directs. They must treat employés with consideration, and see that they properly perform their duties. They must discharge men who are incompetent or neglect their duties, but in no case shall they discharge men without cause. They must keep the required records of the time of their men and of the materials used.

(5) They must each have a copy of the current timetable, and be thoroughly familiar with the rules and regulations therein, and with the time of trains over their districts. They must carefully observe signals displayed by all trains, and assure themselves, before obstructing track, that all trains and sections due have passed. No notice will be given of extra trains, and employés must protect themselves as prescribed by the rules. Foremen must provide themselves with reliable watches, and, when possible, verify time daily with a standard clock or with the watches of other employés who are required to have the standard time.

(6) They must, in case of damage to structures in their districts, promptly proceed to the place with the men, tools and materials at their command, and do all in their power to make necessary repairs.

(7) They must, in case of accident coming under their observation, report the facts to the......................(Title)........................

(8) They shall conform to the prescribed standards, plans and specifications in the execution of the work under their charge.

(9) They shall be responsible for the proper care and use of tools and materials necessary for the efficient performance of their duties, and shall make requisition to the ....(Title).................. from time to time, as additional supply becomes necessary.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They must thoroughly understand the rules, circulars, forms, special instructions and safety regulations pertaining to their duties, and see that they are complied with.

RULES GOVERNING SIGNAL SUPERVISORS.

(1) Signal Supervisors shall report to and receive instructions from the.....................(Title).......................

(2) They shall be responsible for the safe condition and proper maintenance of signals and interlocking plants. They must make temporary repairs of such defects as may endanger or delay the movement of trains, and promptly report defective conditions to the.......(Title)....

(3) They must make frequent inspections of signals and interlocking plants and have necessary repairs made as promptly as conditions require. They must see that all failures of signals and interlocking plants are promptly investigated and report made on Form No. ......

(4) They shall, as necessary, employ men for carrying out the duties for which they are responsible.

(5) They must know that foremen are familiar with the operating rules in regard to train signals and flagging, and that they fully understand and comply with them.

(6) They must, in case of damage to signals or interlocking, promptly assemble forces, tools and materials, and make necessary repairs.

(7) They shall investigate and report on accidents which may be attributable to defects in, or result in damage to, the signal apparatus.

(8) They shall conform to the prescribed standards and plans in the execution of work under their charge.

(9) They must know that foremen are supplied with tools and materials necessary for the efficient performance of their duties, and see that these are properly used and cared for.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They shall keep themselves informed in regard to all work performed in their districts by contrcators, or others who do not come under their charge, see that nothing is done by them that will interfere with the safe operation of signals, and report promptly to the ....(Title)........ if the work is not done in accordance with the prescribed standards.

(12) They shall have immediate supervision of work-train service for the maintenance of signals and interlocking plants in their districts, and employ such service only when authorized by the ....(Title)......

(13) They must know that foremen are provided with the rules, circulars, forms, special instructions and safety regulations pertaining to their duties, and that they fully understand and comply with them.

RULES GOVERNING SIGNAL FOREMEN.

(1) Signal Foremen shall report to and receive instructions from the ....(Title).......................

(2) They shall be responsible for the proper inspection and safe condition of signals and interlocking plants under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

(3) They must make such inspection of the signals and interlocking plants in their districts as the..............(Title)........... may direct, and report all defects found on Form No. ......

(4) They shall employ men as the..............(Title)................ directs. They must treat employés with consideration, and see that they properly perform their duties. They must discharge men who are incompetent or neglect their duties, but in no case shall they discharge men without cause. They must keep the required records of the time of their men and of the materials used.

(5) They must each have a copy of the current timetable, and be thoroughly familiar with the rules and regulations therein, and with the time of trains over their districts. They must carefully observe signals displayed by all trains, and assure themselves, before obstructing track,

that all trains and sections due have passed. No notice will be given of extra trains, and employés must protect themselves as prescribed by the rules. Foremen must provide themselves with reliable watches, and, when possible, verify time daily with a standard clock or with the watches of other employés who are required to have the standard time.

(6) They must, in case of damage to signal or interlocking apparatus in their districts, promptly proceed to the place with the men, tools and materials at their command and do all in their power to make necessary repairs.

(7) They shall investigate and report on accidents which may be attributable to defects in, or result in damage to, the signal apparatus.

(8) They shall conform to the prescribed standards, plans and specifications in the execution of the work under their charge.

(9) They shall be responsible for the proper care and use of tools and materials necessary for the efficient performance of their duties, and shall make requisition to the............(Title)..........from time to time as additional supply becomes necessary.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They must not make nor permit any permanent rearrangement or change in the signals or interlocking plants without proper authority.

(12) They must thoroughly understand the rules, circulars, forms, special instructions and safety regulations pertaining to their duties, and see that they are complied with.

[2] INSTRUCTIONS REGARDING THE CONDUCT OF MAINTENANCE OF WAY WORK.

Cross-Sections.

(1) The roadbed, ballast and track shall conform to the standard plans. No changes in the sections shown shall be made without proper authority. (It is understood that cross-sections for wet cuts will be included in the standard plans.)

Drainage.

(2) All ditches, including intercepting ditches on the upper side of cuts, must be kept clean.

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[2] Adopted, Vol. 13, 1912, pp. 66-68, 919-931; Vol. 14, 1913, pp. 66-69, 1021-1045.

(3) Where heaving or wet spots develop, special drainage shall be provided.

Ballasting.

(4) Before re-ballasting track, line and grade stakes shall be set by the Engineer. All unsuitable material shall be removed and the roadbed widened to the proper section, the waste material being used to widen banks, or otherwise, as may be directed.

(5) Track must be kept in good line and surface while ballasting; open track avoided as far as practicable, and such track carefully watched.

(6) After ballast is distributed and the track lifted, the track should be lined and surfaced and the ballast trimmed to conform to the standard plans.

(7) Where track is electrically bonded, ballast must be kept at least one inch below the base of rail. At road crossings, platforms, etc., where this is not practicable, only clean gravel or rock ballast shall be used.

Ties.

(8) Ties stored along the right-of-way shall be piled to conform to the standard plan. (The standard plan should show the minimum distance to the nearest rail.)

(9) The ties in track must be inspected at stated times each year and those which will not last until the next inspection marked for renewal.

(10) The renewal of ties shall be started when directed by the ....(Title)............. When ties are being renewed, the line and surface shall be corrected, unsuitable material removed and ballast trimmed.

(11) All defective ties removed from track shall each day be placed for burning or loading on cars.

(12) The........(Title)..........shall frequently inspect ties removed from track to see if any of them have been removed which might have remained in the track with safety until the next inspection.

(13) Ties shall be spaced according to the standard plans. All ties shall be placed square to the line of rails. The outside ends on double tracks, and the ends on one side throughout on single track, must be lined parallel with the rail.

(14) Ties must be laid so as to obtain the best bearing. The largest and best ties shall be selected for use at joints. Twisted or badly hewn ties must not be notched, but the bearings must be made true with the adze.

(15) Whenever spikes are drawn from ties, wooden tie plugs must

be driven into all holes except in ties which are to be renewed that season. In replacing spikes they should be driven into the plugs.

Rail.

(16) In unloading rails from cars they should be skidded or otherwise carefully lowered to avoid injury. Where it is necessary to drop them, both ends must be dropped together and the greatest care taken to avoid their falling on hard and uneven surfaces.

(17) The bottom of the new rail and the bearing surface of the tie shall be cleaned before the rail is laid.

(18) When replacing rail with rail of the same section, only two rows of spikes shall be drawn; in replacing with rail of a different section, three rows of spikes shall be drawn, if necessary.

(19) In laying new rail, standard expansion shims shall be used. The temperature of the rail shall be taken by placing the thermometer on the rail. The openings between 33-foot rails should be as follows:

Temperature (Fahrenheit).

—20° to 0°	$\frac{5}{16}$ inch
0° to 25°	$\frac{1}{4}$ inch
25° to 50°	$\frac{3}{16}$ inch
50° to 75°	$\frac{1}{8}$ inch
75° to 100°	$\frac{1}{16}$ inch

Over 100° rail to be laid close.

The rail should be laid without bumping and when practicable, laid rail by rail.

(20) The rails should be brought squarely into line and at least two bolts tightened before spiking. All joint bars shall be securely fastened with the full number of bolts, tightening those at the center first. At permanent connections of rails of different sections compromise joints must be used.

(21) All spikes must be driven vertically with the face in contact with the base of the rail. They should not be straightened while being driven. The rail must be full spiked and the spikes staggered so that the outside spikes shall be on the same side of the tie and the inside spikes on the opposite side.

(22) In making temporary connections in main tracks an old rail should be cut and fastened to the new rail, using compromise joints when necessary.

(23) After new rail is laid the track must be lined and surfaced.

(24) All kinked or crooked rails must be straightened before being laid; if bent in surface they must either be removed or straightened.

(25) Rails for curves of 4 degrees and over should be curved before being laid. In curving or straightening rails, a rail bender must be used.

Surfacing.

(26) When picking up joints or other low places, the general level of the track must not be disturbed.

Tie-Plates.

(27) When tie-plates are used, they should be applied so as to have full bearing upon the tie and for the rail.

Gaging.

(28) Uniform gage is essential to good track and must be maintained.

(29) The standard gage is 4 feet 8½ inches. Curves of eight degrees and under should be standard gage. Gage should be widened one-eighth inch for each two degrees, or fraction thereof, over eight degrees to a maximum of four feet nine and one-quarter inches for tracks of standard gage. Gage, including widening due to wear, should never exceed four feet nine and one-half inches.

(30) The installation of frogs upon the inside of curves is to be avoided wherever practicable; where this is unavoidable the gage of the track at the frog should be standard.

Curve Easement.

(31) On all curves the amount of elevation to be given to the outer rail and the proper easement to be provided at the ends shall conform to the prescribed standards.*

Switches and Frogs.

(32) Switches must be placed in accordance with the standard plans and as located by the Engineer.

(33) Switches and frogs must be kept well lined and in good order. Particular care must be taken to maintain good surface at switches.

(34) Switches must be inspected frequently to see that they are in working order and that all nuts, bolts and other fastenings are in place and properly tightened. Broken or damaged parts must be renewed promptly.

(35) Switch points must fit closely and accurately to the stock rail, which must be bent in accordance with the prescribed standards.*

Switch Ties.

(38) Switch ties must be used for all permanent turnouts, crossovers and railroad crossings and placed as shown on the standard plans.*

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* American Railway Engineering Association Standards for Track.

Guard Rails.

(39) Frogs must be protected by guard rails, constructed and placed in accordance with the standard plans.* The tops of the guard rails must be level with the tops of the main rails and must be securely held in place.

(40) Guard rails must be so placed that the gage distance from the frog point to the flangeway side of the guard rail should be at least 4 feet 6¾ inches, and the distance between flangeway sides of the wing rail and guard rail shall not exceed 4 feet 5 inches.

Track Posts and Signs.

(41) All signal posts, whistle posts, mile posts, signal targets, bridge and other standard signs must be kept plumb and in good condition.

(42) Whistle posts must be placed so as not to be obscured by fences or other signs.

Care of Track Tools.

(43) Tools must not be left where they are liable to be struck by trains.

Road Crossings.

(44) Road and street crossings must be constructed as shown on the standard plans and kept in good order.

(45) Particular care must be taken to remove as far as practicable all obstacles which obstruct the view of crossing signs and approaching trains.

(46) Flangeways must be kept clear of rubbish, snow, ice and other obstructions; defective crossing planks must be repaired promptly.

Platforms.

(47) Station platforms must be kept clean, free from rubbish, snow and ice, and in good order.

(48) Defective platforms must be promptly repaired or reported.

Fences and Stock Guards.

(49) Fences and gates along the right-of-way shall be kept in repair and all gates kept closed when they are not in actual use.

(50) Stock guards must be kept in repair and at all times free from dirt, rubbish and other obstructions.

Track Jacks.

(51) Track jacks must not be used between the rails of main tracks, except in unavoidable cases; and then only under flag protection as prescribed in rule 53.

RULES GOVERNING THE USE OF STOP AND CAUTION SIGNALS FOR THE PROTECTION OF UNSAFE AND OBSTRUCTED TRACK.

Flagging.

(52) In case of impassable track, flagging is the first duty, and repairs must wait, if necessary, until signals have been placed.

Flagging Before Obstructing Track.

(53) The track must never be obstructed without first displaying stop signals in general accord with rule 99 of the American Railway Association. Stop signals must be in the hands of reliable men. Flagmen must stop all trains and explain to the engineman the nature of the obstruction and its exact location.

Slow Orders.

(54) When the track is not in condition for the passage of trains at the usual rate of speed, and this condition will continue over night or for the greater portion of a day, notice must be given immediately to the ....(Title)................ In such notices the place of danger, its nature and the speed at which trains may pass must be stated.

In addition to sending this notice, slow (color) signals must be displayed. When repairs have been made the person making them must at once notify the..............(Title).................that the slow order may be recalled.

Signals to Be Used.

(55) The color, hand, flag, lamp and engine steam whistle signals, and the train markers prescribed by and published in the Standard Code of The American Railway Association shall be used. (It is suggested that copies of the description and rules for the use of these signals, including diagrams, be inserted in books of rules governing maintenance of way employés.)

Time for Obstructing Track.

(56) All work which will obstruct the track must be done at such times as will interfere as little as practicable with the passage of trains.

Obstructing Track in Storm or Fog.

(57) Except in emergency, no work that will obstruct the track shall be done during fogs or storms.

Signals in Obscure Weather.

(58) In obscure weather, or on heavy grades or curves, extraordinary care must be taken to make sure that the stop signals are displayed at a proper distance in both directions to insure full protection.

Proper Maintenance of Signals.

(59) While working under the protection of signals, great care shall be taken that the signals are intact and in their proper location and position. Disregard of signals shall be promptly reported to the.....(Title).....

Signals for Double Track.

(60) Each main track shall be considered as a single track railroad upon which trains are likely to be run in either direction at any time, and signals must be displayed accordingly.

RULES GOVERNING THE USE OF HAND, PUSH, MOTOR AND VELOCIPEDE CARS.

(61) Care must be exercised by foremen and other employés in the use of hand, push, motor and velocipede cars. In order to avoid accident, they must protect themselves with the proper signals when the view is obstructed. On moving hand cars at least one man must face the rear to look out for approaching trains.

62. Such cars must be protected from the weather and when left alone must be locked.

(63) Cars must never be used or left unprotected on the main tracks or sidings, street or highway crossings. Loaded hand or push cars on the track are obstructions and must be protected by the proper signals.

(64) They must not be attached to trains. When following trains, or other moving cars, they must not run closer than ten (10) rail lengths.

(65) They must be kept in good order and inspected frequently for loose bolts or other defects.

(66) Main track switches must not be thrown for such cars, unless loaded, and then only under the supervision of the foreman.

[8] SAFETY RULES.

(1) It is the duty of every employé working on or about the tracks to exercise great care to avoid injury to himself and others, and nothing in these rules is to be so construed as to relieve any employé from performing his full duty in that respect.

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[8] Adopted, Vol. 16, 1915, pp. 66, 1023.

(2) Employés must examine and know for themselves that tools, materials, etc., which they must make use of in performing their duties are in proper condition. If not, they must put them so, or report them to the proper person and have them put in proper order before using.

(3) In handling rails, ties and other heavy materials, special care must be used to avoid injury.

(4) On the approach of a train, employés who are working on or about the tracks must move to places of safety, standing clear of all running tracks. They must not walk or stand on the tracks, except when necessary for the proper performance of their duties.

(5) Watchmen, patrolmen, trackwalkers and others on duty which makes it necessary for them to be on the track, where there are two or more tracks, should, when practicable, travel against the current of traffic, keeping a sharp lookout in both directions for approaching trains.

(6) Foremen or others in charge of employés must see that their men are alert and watchful to avoid danger; and when working on or about the tracks will take the necessary precautions to see that all men working under their immediate supervision receive warning of approaching trains in time to reach places of safety.

(7) When working on tracks in places where approaching trains cannot readily be seen because of permanent obstruction to the view, curves, or temporary obstructions, such for instance as fog, storms, snow, or engines or cars, extra precautions must be taken to warn the men of approaching trains.

Foremen, watchmen, and others in charge of gangs or squads of workmen should provide themselves with whistle or other means for warning the men when working in places where approaching trains cannot readily be seen.

(8) When large numbers of inexperienced men are working on the track, they should be divided into small squads, each squad placed in charge of an experienced man, and all necessary additional precautions taken to prevent accident.

(9) Employés working in tunnels or near the ends of the same when trains approach from either direction, must clear all tracks, and if in the tunnel, must occupy the manholes.

(10) In tunnels where there is insufficient clearance and no manholes or other places of safety provided, foremen must arrange with the superintendent for the use of track and work under flag protection.

(11) Employés are required to carry lanterns or torches when passing through any tunnel where men cannot readily be seen.

When an entire gang is working close together in a tunnel, an adequate number of lights should be used, but not less than two.

(12) Hand or push cars must not be used at night, nor in the daytime when approaching trains cannot readily be seen by reason of fog, storm or snow, except under proper protection.

(13) Trains will be run in either direction, on any track, whenever necessary or expedient, and employés will be governed accordingly.

(14) Employés will keep the right-of-way, and particularly the main, yard and sidetracks and the footpaths along them, free of obstacles, such as old material, broken drawbars, lumps of coal, and anything over which themselves or others may stumble.

(15) Any employé, who, while on duty, is careless about the safety of himself or others, or who disregards warnings, will be disciplined.

[4] GENERAL RULES FOR THE GOVERNMENT OF EMPLOYES OF THE CONSTRUCTION DEPARTMENT.

GENERAL NOTICE.

(1) To enter or remain in the service is an assurance of willingness to obey the rules.

(2) The service demands the faithful, intelligent and courteous discharge of duty.

(3) Obedience to the rules is essential to the safety of passengers and employés, and to the protection of property.

(4) Employés must exercise care and watchfulness to prevent injury to themselves, fellow-employés and the public, and to prevent damage to property. In case of doubt they must take the safe course. They must know that all tools and appliances are in safe condition before using. They must move away from tracks upon approach and during passage of trains, and, so far as practicable, prevent the public from walking on tracks or otherwise trespassing on the right-of-way. They must familiarize themselves with the safety regulations of the Company.

(5) Employés must do all in their power to prevent accidents, even though in so doing they occasionally perform the duties of others.

(6) Co-operation is required between all employés whose work or duties may be jointly affected.

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[4] Adopted, Vol. 15, 1914, pp. 67, 1005, 1006.

(7) Anything that interferes with the safe passage of trains at full speed is an obstruction.

(8) Employés in accepting employment assume its risk.

(9) To obtain promotion, capacity must be shown for greater responsibility.

(10) Employés must not absent themselves from duty, exchange duties with others or engage substitutes, without permission.

(11) Employés must conduct themselves properly at all times. They will be courteous to fellow-employés and the public.

ORGANIZATION.

(1) The Construction Department in each........District or etc. ....is in charge of the........(Title)............who will report to and receive instructions from the ....(Title).........

(2) The work of the department will be sub-divided under the following heads:

Preliminary Surveys.	Chief of Party..............(or Title)..........
Location Surveys.	Chief of Party..............(or Title)..........
Construction.	Resident Engineer.

RULES GOVERNING CHIEFS OF PARTY ON PRELIMINARY LOCATION SURVEYS AND RESIDENT ENGINEERS.

(1) Chiefs of Party
Resident Engineers } will report to and receive instructions from the ....(Title)..........

(2) They are responsible for the prosecution of the work in accordance with the general rules and special instructions, and will make such reports as are required.

(3) They shall keep their parties up to the required strength and report any prospective vacancies to the...............(Title)................

(4) They are responsible for the conduct of the members of their parties and must know that each man is competent to do the work required of him.

(5) They shall conform to the prescribed instructions, standards and plans in the execution of work under their charge.

(6) They must keep their parties supplied with the instruments and materials necessary for the efficient performance of their work, and see that these are properly cared for and used.

(7) They must know that instruments are kept in proper adjustment and that the prescribed accuracy is attained in all their work.

(8) They must not give out information as to the object or character of their work and must refer all inquiries to the..........(Title)..........

(9) They shall keep themselves informed in regard to the work of other survey parties operating in their districts and report to the ....(Title)........ anything that will have an influence on their work.

(10) They must know that their parties are provided with the rules, standards, circulars, forms, special instructions and safety regulations pertaining to their work, and that they are fully understood by the men to whom they apply.

(11) They shall keep a daily journal of the movements of their parties and the work done, and will enter therein current items of information of which it is advisable to keep record.

COMMITTEE XIII.

WATER SERVICE.

[1] QUALITY OF WATER, METHODS OF TREATMENT AND RESULTS OBTAINED THEREFROM.

(1) In locating water stations along a railway, an investigation should be made of all the available water supplies, and care should be taken to avoid the use of poor water, or to curtail its use as much as possible.

(2) Most water used in locomotive boilers contains scale-forming matter in solution or suspension, causing trouble and expense in the operation and maintenance of locomotives.

(3) Hard water can be softened before it is put into locomotive boilers by treatment with chemicals.

(4) The hardness of water due to carbonates of lime and magnesia can be removed at a moderate expense for chemicals by the use of lime alone, without adding any soluble salts to the softened water.

(5) The hardness of water due to sulphates of lime and magnesia can be removed by the use of soda ash, a more expensive chemical. The chemical reaction removes sulphates of lime and magnesia, and leaves soluble sulphates of soda, which increase the tendency to foam.

(6) The removal of sulphates of lime and magnesia is of greater moment than the removal of the carbonates alone, as the carbonates of lime and magnesia, without the presence of the sulphates of lime or magnesia, do not form hard scales, but are precipitated in the boiler as soft scale and mud.

(7) Water softeners differ widely as to their mechanical features, but they consist of two general types, the continuous and the intermittent.

(8) At stations where hard water is used, special study should be made relative to the economical value of treating the water, and the method best adapted to meet the conditions.

(9) The cost of installing a water-softening plant varies according to the capacity of the plant, its type, cost of material and labor in the particular locality, and other local conditions.

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[1] Adopted, Vol. 9, 1908, pp. 110-112, 154; Vol. 11, Part 2, 1910, pp. 1143, 1144, 1219.

(10) The cost of operating a water-softening plant varies according to the efficiency of the water-softening apparatus and the cost of lime and soda ash, or other chemicals available for softening water in the particular locality.

(11) The amount of chemicals required to soften water varies according to the quantity of hardening matter in the water, and also its composition.

(12) The benefits derived from water-softening plants are: Fewer boiler failures due to leaking; longer life of flues and firebox sheets; reduced cost of labor for repairing and washing boilers; increased locomotive mileage between shoppings; decreased number of locomotives required to perform the same service; less expense in cost of overtime and delays; saving in fuel.

(13) The greatest disadvantage in treating water is the increased tendency to foam, due to the reaction of soda ash on the sulphates of lime and magnesia.

[2] EFFICIENCY OF WATER SOFTENERS.

(A) DESIGN AND INSTALLATION.

(1) Special study should be made relative to the economical value of treating the water, and the method best adapted to meet the conditions.

(2) The installation of softening plants should follow a systematic plan. Greater success is generally obtained by completing the installation on one division first, rather than installing plants at individual points of especially bad water.

(3) Feasibility of treatment of a given water should be carefully investigated. Waters containing large proportions of incrusting sulphates alone or in combination with quantities of alkali salts may be entirely unusable after treatment.

(4) The plant should be of adequate capacity. It is necessary to anticipate possible increases in the consumption of water at the station considered.

(5) The mechanical device for introducing reagents should be such as to insure as near as possible a quantity of reagents in direct proportion to the flow of the untreated water. It should be simple of construction and operation and not readily thrown out of adjustment.

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[2] Adopted, Vol. 8, 1907, pp. 604-607, 615, 617, 620; Vol. 16, 1915, pp. 678, 1133.

(B) OPERATION, MAINTENANCE AND SUPERVISION.

(1) Adequate supervision is necessary to successful operation of a softening plant. Such supervision should be exercised at least in part by a chemist, or an Engineer having adequate knowledge of water treatment.

(2) Provision should be made for frequent analyses or hardness tests of both treated and raw water. This is necessary, principally as a check on the treatment, and also on account of changes in the condition of the raw water.

In order that the analyses shall be effective, they must be made under the supervision of a competent chemist.

(3) Where consumption of water is in excess of the rated capacity of the plant, the use of undertreated, milky water should be avoided by the use of raw water to such an extent as to give ample time for the proper treatment of all water that passes through the softener. The exception to this rule is the case of water which is being treated for corrosive properties. Such water should not be used raw if it can be avoided.

(4) The solutions containing the reagent should be properly prepared.

(5) The reagents should be as near chemically pure as practicable.

(C) CAPACITY OF WATER SOFTENERS.

Where the lime and soda ash treatment is used, the volume of space for reaction and precipitation should be at least from three to four times the hourly capacity of the softener, depending on temperature and analysis of the water.

The equations for determining this space for both types of softeners, and Table 1, given below, conform to good practice.

In a continuous softener, the volume of the chambers through which the water passes, between the top of the portion reserved for sludge and the outlet through which the water finally flows to the storage tank, should be at least three times the hourly capacity of the plant, and where the temperature of the water is low, it should be four times the hourly capacity.

The determination of the number and volume of settling tanks for intermittent softeners depends on the number of pumps or batteries of pumps necessary to handle the water; time required to fill or empty each settling tank, above the sludge line, and time necessary for reaction and precipitation.

Where gravity flow, both to and from the softener, cannot be obtained, pumps should be provided with intermittent plants, as follows:

One Pump Only is Necessary:

(a) Where water is pumped to settling tanks and is transferred by gravity to storage tanks.

(b) Where water flows by gravity to settling tanks, and is transferred to storage tank by pumping.

(c) Where water is pumped to both the settling and storage tanks and the source of supply is ample to furnish double the capacity of the softening plant.

Two Pumps are Necessary:

(d) Where deep well pumps furnish supply and water must be pumped from settling tanks to storage tanks.

(e) Where water is handled by pumping to both settling and storage tanks, but the source of supply is not ample to furnish at least double the capacity of the plant.

In all of the cases where pumps are needed, excepting case "c," the capacity of each pump, or battery of pumps, used for each operation should at least be equal to the treating capacity of the softener. If the pumps used to transfer the treated water are of a larger capacity, so that water can be transferred to storage tanks in less time than is required to fill the settling tanks, less settling tank capacity will be required.

In case "c," as the pump must handle the water twice in its transfer from the source of supply through the softener and into the storage tank, its capacity should at least be equal to double the capacity of the softener, and the supply should be sufficient for the pump.

At least three feet of the depth of each settling tank should be reserved for the accumulation of the precipitates; therefore, in estimating the settling space needed and the capacity of settling tanks, the settling space should be considered as lying entirely above this reserved portion.

With these points in view, the proper capacity for settling tanks, measured above the space reserved for sludge, can be determined as follows:

$a =$ capacity of softener in gallons per hour.

$b =$ hours required for reaction and precipitation.

$c =$ number of settling tanks (never less than 2).

$x =$ number of hours required to fill the portion of settling tank above the "sludge" portion.

y = number of hours required to transfer treated water from one settling tank to the storage tank. (y should never be greater than x.)

In case "c," where one pump alternates between filling and emptying settling tanks, the time for filling and emptying the total number of tanks less one must equal the time for reaction and precipitation in that one, and x would equal y. As the capacity of the pump must be double the capacity of treating plant, the settling capacity in each tank would be $2ax$.

The equations expressing the above are:

$$2x\,(c-1) = b$$

$$x = \frac{b}{2c-2}$$

Settling capacity each tank $= 2ax = \dfrac{2ab}{2c-2} = \dfrac{ab}{3-1}$.

For plants where the quantity of water supplied to the softener and the capacity of the plant are equal, the settling capacity of each tank is equal to ax. The total number of hours required to fill all the settling tanks should equal the number of hours required to fill, precipitate and empty one tank, as expressed by the following equation:

$$cx = x + b + y$$

$$x\,(c-1) = b + y$$

$$x = \frac{b+y}{c-1}$$

If $y = x$, then $x = \dfrac{b}{c-2}$; and $ax = \dfrac{ab}{c-2}$.

If $y = \frac{1}{2}x$, then $x = \dfrac{b}{c-1.5}$; and $ax = \dfrac{ab}{c-1.5}$.

TABLE 1. PROPER SETTLING CAPACITY OF TANKS ABOVE THE PORTION RESERVED FOR SLUDGE, UNDER VARIOUS CONDITIONS OF OPERATION IN INTERMITTENT WATER SOFTENERS.

Number of Tanks. "c"	Time required, Each Tank.			Settling Capacity of Tanks per 1000 Gallons, Capacity of Softener.	
	Filling. "x"	Reaction. "b"	Emptying. "y"	Each Tank.	Total.
When flow of water to softener is double the capacity of softener.					
2	2 Hours	4 Hours	2 Hours	4,000 Gals.	8,000 Gals.
3	1 "	4 "	1 "	2,000 "	6,000 "
4	⅔ "	4 "	⅔ "	1,333 "	5,333 "
2	1½ "	3 "	1½ "	3,000 "	6,000 "
3	¾ "	3 "	¾ "	1,500 "	4,500 "
4	½ "	3 "	½ "	1,000 "	4,000 "
When flow of water to softener equals the capacity of softener.					
3	4 Hours	4 Hours	4 Hours	4,000 Gals.	12,000 Gals.
4	2 "	4 "	2 "	2,000 "	8,000 "
5	1⅓ "	4 "	1⅓ "	1,333 "	6,667 "
6	1 "	4 "	1 "	1,000 "	6,000 "
2	8 "	4 "	4 "	8,000 "	16,000 "
3	2⅔ "	4 "	1⅓ "	2,667 "	8,000 "
4	1⅗ "	4 "	⅘ "	1,600 "	6,400 "
5	1⅐ "	4 "	4/7 "	1,143 "	5,714 "
3	3 "	3 "	3 "	3,000 "	9,000 "
4	1½ "	3 "	1½ "	1,500 "	6,000 "
5	1 "	3 "	1 "	1,000 "	5,000 "
2	6 "	3 "	3 "	6,000 "	12,000 "
3	2 "	3 "	1 "	2,000 "	6,000 "
4	1⅕ "	3 "	⅗ "	1,200 "	4,800 "
5	6/7 "	3 "	6/7 "	857 "	4,286 "

Table 1 is developed from these equations and gives the proper settling capacity per 1000 gallons per hour capacity of treating plant under various conditions and varying number of settling tanks. From this table it will be noted that with the same time allowed for reaction and precipitation, the least number and the smallest capacity of settling tanks is required where the flow of the untreated water to the softener is double the hourly capacity of the softener, and the one pump works alternately filling and emptying these tanks. Where pumping is a necessity and sufficient supply can be obtained, the one-pump plan will be the most economical in maintenance and operation of the intermittent plants.

[3] RELATIVE ECONOMY OF DIFFERENT TYPES OF SOFTENERS.

The relative economy of the different types of water softeners can be determined by comparing the total annual cost of each, exclusive of the cost of chemicals. This annual cost should be composed of:

(a) Interest on the sum of the cost of installation and value of ground space occupied;
(b) Depreciation;
(c) Current running repairs;
(d) Additional labor and fuel required above the ordinary cost of operating the water station.

[4] REAGENTS USED IN WATER-SOFTENING.

The quantity of reagents required per unit of scaling or corroding substance held in solution, given in Table 2, is recommended as good practice.

Where the commercial product is not chemically pure, the proportion of reagents should be increased to correspond with an equivalent quantity of pure reagent.

Given the analysis of a water, the pounds of incrusting or corrosive matter held in solution per 1000 gallons can be obtained by dividing the grains per gallon of each substance by seven, or the parts per 100,000 by twelve.

By using Table 2, the quantity of reagents per 1000 gallons can be readily calculated, and by applying local cost of the same, the cost for chemicals per 1000 gallons will be obtained. In order to ascertain the full amount of lime necessary, the amount of free carbonic acid contained in the water should be determined, as well as the solids contained in solution, since this free acid must be eliminated in order to obtain efficient treatment of water and reduce scaling matter to the minimum.

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[3] Adopted, Vol. 8, 1907, pp. 615, 620.
[4] Adopted, Vol. 8, 1907, pp. 608-610, 615, 621.

TABLE 2. QUANTITY OF PURE REAGENTS REQUIRED TO REMOVE ONE POUND OF INCRUSTING OR CORROSIVE MATTER FROM THE WATER.

Incrusting or Corrosive Substance Held in Solution.	Amount of Reagent (Pure)	Foaming Matter Increased.
Sulphuric acid	0.57-lb. lime plus 1.08 lbs. soda ash	1.45 lbs.
Free carbonic acid	1.27 lbs. lime	None
Calcium carbonate	0.56-lb. lime	None
Calcium sulphate	0.78-lb. soda ash	1.04 lbs.
Calcium chloride	0.96-lb. soda ash	1.05 lbs.
Calcium nitrate	0.65-lb. soda ash	1.04 lbs.
Magnesium carbonate	1.33 lbs. lime	None
Magnesium sulphate	0.47-lb. lime plus 0.88 lb. soda ash	1.18 lbs.
Magnesium chloride	0.59-lb. lime plus 1.11 lbs. soda ash	1.22 lbs.
Magnesium nitrate	0.38-lb. lime plus 0.72 lb. soda ash	1.15 lbs.
Calcium carbonate	3.15 lbs. barium hydrate	None
Magnesium carbonate	3.76 lbs. barium hydrate	None
Magnesium sulphate	2.62 lbs. barium hydrate	None
*Calcium sulphate	2.32 lbs. barium hydrate	None

*In precipitating the calcium sulphate, there would also be precipitated 0.74-lb. of calcium carbonate or 0.31-lb. of magnesium carbonate, the 2.32-lbs. of barium hydrate performing the work of 0.41-lb. of lime and 0.78-lb. of soda ash, or for reacting on either magnesium or calcium sulphate, 1-lb. of barium hydrate performs the work of 0.18-lb. of lime plus 0.34-lb. of soda ash, and the lime treatment can be correspondingly reduced.

[5] FOAMING AND PRIMING.

Foaming from treated water is due to the presence of sodium salts, as a result of treatment for incrusting sulphates, together with such quantities of the alkali salts which may have been present in the raw water. This condition is aggravated and to a large extent due to the presence of suspended matter in the water.

Concentration of foaming solids in locomotive boilers reaches the critical point at about 100 grains per gallon. Concentration above this point must be avoided by changing the water, or else trouble from foaming will be experienced.

The grains per gallon of foaming matter in solution represent the minimum per cent. of water which must be wasted in locomotive boilers to keep the concentration at the critical limit.

In other words, for each pound of foaming matter per 1000 gallons of water, the expense would be equal to the cost of pumping and treating at least 70 gallons of water, and the fuel for heating the same to the temperature of boiling water.

Aside from occasional complete change of water at terminals, partial changes are made by blowing-off of boilers either at terminals or on the road.

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[5] Adopted, Vol. 8, 1907, pp. 615, 616, 621; Vol. 16, 1915, 679, 1133.

The most efficient results are obtained by systematic, frequent blowing-off of the boilers on the road, as well as at terminals, together with occasional complete blowing-down and washing of boilers.

There are, of course, conditions where concentration of foaming solids is so great that the required amount of blowing-off would be both impracticable and uneconomical, and it is necessary to resort to anti-foaming compounds.

[6] MINIMUM QUANTITY OF SCALING AND CORROSIVE MATTER WHICH WILL JUSTIFY TREATMENT.

The minimum quantity of solids in solution that will justify treatment depends on local conditions and the composition of the solids. By applying the proper local values to the equation given below, this quantity can be determined.

The following equation gives the point where the benefits derived from treating the water will balance the cost of treating:

$X =$ Number cwt. (100 lbs.) solids removed from water per annum.

$B =$ Money value of benefits obtained from removing 100 lbs. solids; this will include:

Saving in boiler washing and repairs;

Saving in fuel.

Increased service obtained from locomotives, represented by the interest on the cost of the additional number of locomotives that would be required to perform the service rendered by locomotives using the soft water, if based on the performance prior to treating the water.

$C =$ Cost per 100 lbs. of solids removed to operate the plant, as follows:

Additional cost of labor;

Additional cost of fuel or power;

Cost of chemicals;

Cost of current repairs.

$D =$ Cost of plant installed.

$I =$ Interest per annum on D.

$L =$ Estimated useful life of plant in years.

$R =$ Estimated value of materials recovered from plant after L years.

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[6] Adopted, Vol. 8, 1907, pp. 612, 613, 616, 622.

S = Annual depreciation of plant, equivalent to a sum per year which, if placed in a sinking fund at I rate of interest, would amount to $D-R$ in L years. (See table, page 16, Kent's Pocket Book.

The benefits would balance the cost when

$$XB = XC + I + S. \tag{1}$$

$$X = \frac{I+S}{B-C} \tag{2}$$

The number of pounds solids removed daily to make benefits equal the cost would be $\dfrac{I+S}{3.65\,(B-C)}$ (3)

If more than this amount of solids is removed the plant will be economical.

Values for B can only be fixed for each particular case, as some of the matter held in solution is more injurious than the same weight of other matter.

[7] GENERAL PRINCIPLES OF WATER SUPPLY SERVICE.

SUPPLY—QUANTITY.

The supply (if possible within economical limits) should be sufficient so that the total amount of water likely to be required during the average volume of business in twenty-four hours can be drawn from the source in seven hours at terminal stations and in four hours at intermediate stations.

SUPPLY—SOURCE.

Where water of suitable quality and in sufficient quantity can be purchased at reasonable figures, it is recommended above all other sources.

Springs should be carefully gaged for a period of at least one year, and the possibility of future pollution and increased demands for supply therefrom carefully considered before adoption as a permanent source. A reservoir should be constructed at the spring where conditions permit.

Lakes, natural ponds, creeks or rivers require special investigation in each case. The points to be considered are quantity, quality—as regards chemical impurities and amount of sediment carried—future pollution and riparian rights. The style of intake will depend on local conditions entirely; no definite rule can be given.

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[7] Adopted, Vol. 10, Part 1, 1909, pp. 735-765, 810-814.

Dug well construction should always be preceded by a careful auger test to determine the strata to be encountered. Size and construction depend on the strata to be passed through; no definite rule can be given.

Surface pipe wells are satisfactory where local conditions permit of their use. This system is one which can be extended to collect a large volume of ground water. The recommended layout is shown in Fig. 1.

Artesian deep wells, where obtainable, are a satisfactory source; however, their flow is liable to constant decrease and finally cease.

Deep wells requiring pumping are recommended only as a last resort. The recommended form for record is shown on M. W. 1304.

A chemical analysis should be made of all water, and the question of cost of treatment, if required, thoroughly investigated, as outlined under the heading "Minimum Quantity of Scaling and Corrosive Matter which will justify Treatment."

PUMPING PLANTS.

The size of the plant should be in accordance with the following table:

Quantity per 24 Hours, in Gallons.	Terminal Stations.		Intermediate Stations.	
	Time Pump to Run in 24 Hours.	Gallons per Minute.	Time Pump to Run in 24 Hours.	Gallons per Minute.
2,000,000	20 Hours......	1666	20 Hours......	1666
1,750,000	20 Hours......	1458	20 Hours......	1458
1,500,000	20 Hours......	1250	20 Hours......	1250
1,250,000	20 Hours......	1042	20 Hours......	1042
1,000,000	20 Hours......	833	20 Hours......	833
900,000	20 Hours......	733	20 Hours......	733
800,000	20 Hours......	666	20 Hours......	666
700,000	20 Hours......	583	20 Hours......	583
600,000	20 Hours......	500	10 Hours......	1000
500,000	7 Hours......	1189	10 Hours......	833
450,000	7 Hours......	1071	10 Hours......	750
400,000	7 Hours......	928	10 Hours......	666
350,000	7 Hours......	838	10 Hours......	583
300,000	7 Hours......	714	10 Hours......	500
250,000	7 Hours......	595	4 Hours......	1041
200,000	7 Hours......	476	4 Hours......	833
150,000	7 Hours......	357	4 Hours......	625
100,000	7 Hours......	238	4 Hours......	416
50,000	7 Hours......	119	4 Hours.... .	208
25,000	7 Hours......	60	4 Hours......	104

Size of discharge pipe should be decided in accordance with the following:

Use 4-in. Cast-iron Pipe where Qd × H is most nearly equal to 0.355
Use 6-in. Cast-iron Pipe where Qd × H is most nearly equal to 0.437
Use 8-in. Cast-iron Pipe where Qd × H is most nearly equal to 0.519

Use 10-in. Cast-iron Pipe where $Qd \times H$ is most nearly equal to 0.656
Use 12-in. Cast-iron Pipe where $Qd \times H$ is most nearly equal to 0.820
Use 14-in. Cast-iron Pipe where $Qd \times H$ is most nearly equal to 1.162

When $Qd =$ average quantity of water pumped per 24 hours in 1000 gallons and $H =$ friction head in feet for one foot of pipe for quantity of water plant is to handle per minute.

The static head should be obtained. Friction head should be calculated in accordance with friction tables and 50 per cent. added thereto for the ageing of the piping system.

The E.H.P. will be

$$\frac{\text{Gallons per minute} \times (\text{static head} + \text{friction head in feet})}{3960}$$

Steam should be selected for power for plants up to 5 E.H.P. when most of the following conditions obtain:

(a) Where 100 lbs. of coal unloaded into a pump house is cheaper than one gallon of oil delivered at oil storage tank, taking into consideration the number of hours the plant is to be operated and the location of plant as regards delivery of fuel; special attention also being paid to the proper design of pump as regards size of steam and water cylinders in large plants.

(b) Where a steam plant is maintained for other purposes, as at terminals where shops are run by steam.

(c) Where interest charge on a steam plant is less than it would be on an oil plant.

Oil should be selected as a motive power where most of the following conditions obtain:

(a) Where one gallon of oil delivered at oil storage tank is cheaper than 100 lbs. of coal unloaded into the pump house, special consideration being given to locations remote from trackage and isolated stations where train service is such that pumper can, by pumping the whole of his time between trains, do the pumping at two or three stations.

(b) Where the quality of the water is such that it will necessitate heavy boiler repairs, provided boiler compounds cannot be successfully used.

(c) Where interest charge on an oil plant is less than it would be on a steam plant.

The boiler selected should have the relation to E.H.P., as shown by the following table, and should carry 100 lbs. steam.

SIZE OF VERTICAL SUBMERGED FLUE AND LOCOMOTIVE TYPE BOILERS FOR RAILROAD PUMPING PLANTS FROM 1 TO 15 EFFECTIVE HP.

NOTE:—These calculations are based on boiler pressure, 100 lbs.; pump cylinder pressure, 90 lbs.; coal, 11,000 B. T. U., 25 per cent. added for contingencies; pump efficiency, 66⅔ per cent.

E. H. P. = Gal. per Min. × Head in Ft. ÷ 4000	I. H. P. at 66⅔% Pump Efficiency	Lbs. Water per Hour at 65° F. to Steam at 100 lbs., to be Evaporated at 36½ lbs. per I. H. P.	Sq. Ft. Heat Surface Required for Evaporation at 2.88 Lbs. Water per Hour, per Sq. Ft. Heating Surface	Boiler H.P. at 10 Sq. Ft. Heat Surface per H.P. per Hour. 25% Added for Contingencies		Lbs. of Coal at 11,000 B. T.U. Burned per Hour to Evaporate Water, Using 2.8 lbs. per E.H.P. Hour	Sq. Ft. Grate Area Required for Consumption of 13 lbs. Coal per Sq. Ft. per Hour (Given as Most Economical by Christie Tests.)	Sq. Ft. Grate Area Usually Furnished in Boilers		Lbs. of Coal of 11,000 B. T. U. Burned per Sq. Ft. Grate per Hour to Evaporate Water in Boilers as Usually Furnshd.	
				Actual	Nearest Com'l			Vertical	Loco	Vertical	Loco
1	1.5	55	19	2.8	5	28	2.15	1.76	Not Made	15.8	Not Made
2	3.0	110	38	4.8	5	56	4.32	1.76		31.8	
3	4.5	164	57	7.2	8	84	6.47	3.14		26.7	
4	6.0	219	76	9.5	10	112	8.52	3.14		35.6	
5	7.5	274	95	12.0	12	140	10.80	3.14		44.5	
6	9.0	329	114	14.0	15	168	12.90	4.90	6.3	34.2	26.6
7	10.5	384	134	16.8	20	196	15.00	7.10	9.2	27.6	21.3
8	12.0	438	152	19.0	20	224	17.20	7.10	9.2	31.5	24.3
9	13.5	492	170	21.3	25	252	19.40	7.10	9.2	35.4	27.4
10	15.0	548	188	23.5	25	280	21.60	7.10	9.2	39.5	30.5
11	16.5	603	208	26.1	30	308	23.70	9.60	12.2	32.0	25.2
12	18.0	654	227	28.4	30	336	25.80	9.60	12.2	34.8	27.5
13	19.5	713	247	30.8	35	364	27.00	9.60	12.2	37.9	29.8
14	21.0	768	265	33.2	35	392	30.00	9.60	12.2	40.8	32.1
15	22.5	822	285	35.6	40	420	32.30	9.60	12.2	43.7	34.3

The steam pump selected should have the ratio of water to steam cylinders as large as possible. The water cylinder should be of proper size to discharge the required amount of water per minute, assuming 70 strokes per minute for each cylinder. Pump efficiency should be assumed as 66⅔ per cent. Assuming initial steam pressure at 90 lbs. per square inch obtain steam cylinder pressure per pound water pressure. Proper ratio of water to steam cylinder should be as per Fig. 1. The size of steam cylinder should be in accordance with this size of water cylinder and ratio (see Table 3).

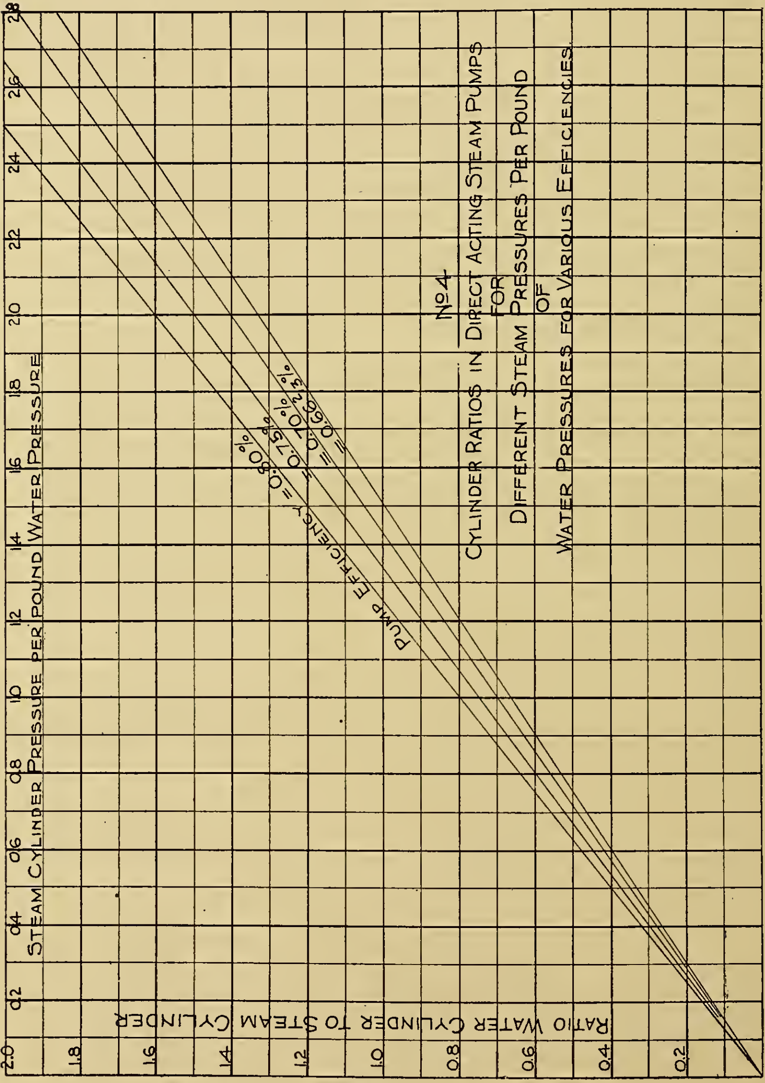

FIG. 1.

TABLE 3

Table Showing Ratio of Area of Water Cylinders to Steam Cylinders for Various Standard Sizes Direct Acting Steam Pumps

$$\text{Ratio} = \frac{\text{Area of Water Cylinder}}{\text{Area of Steam Cylinder}}$$

Diameter Cylinders		Ratio	Diameter Cylinders		Ratio	Diameter Cylinders		Ratio
Steam	Water		Steam	Water		Steam	Water	
6	5	0.69	6	7½	1.56	7	10	2.04
7	5	0.51	7½	7½	1.00	8	10	1.56
7½	5	0.44	8	7½	0.88	10	10	1.00
8	5	0.39	12	7½	0.39	12	10	0.69
9	5	0.31	14	7½	0.29	14	10	0.51
10	5	0.25	16	7½	0.22	16	10	0.39
						17	10	0.35
5	5½	1.21	6	8	1.78	18	10	0.31
5½	5½	1.00	8	8	1.00	20	10	0.25
6	5½	0.84	10	8	0.64	22	10	0.21
10	5½	0.30	12	8	0.44			
12	5½	0.21	14	8	0.33	7½	10¼	1.87
			16	8	0.25	9	10¼	1.30
5¼	5¾	1.20				10	10¼	1.05
6	5¾	0.92	6	8½	2.01	12	10¼	0.73
7½	5¾	0.59	7	8½	1.48	14	10¼	0.54
			7½	8½	1.28	16	10¼	0.41
6	6	1.00	8	8½	1.13	17	10¼	0.36
7	6	0.73	9	8½	0.89	18½	10¼	0.31
7½	6	0.64	10	8½	0.72	20	10¼	0.26
8	6	0.56	12	8½	0.50			
9	6	0.44	14	8½	0.37	17	11	0.42
10	6	0.36	16	8½	0.28	20	11	0.30
12	6	0.25	17	8½	0.25			
			18	8½	0.22	8	12	2.25
5¼	6¾	1.65	18½	8½	0.21	9	12	1.78
7	6¾	0.93				10	12	1.44
			14	9	0.41	12	12	1.00
6	7	1.36	16	9	0.32	14	12	0.73
7	7	1.00	18	9	0.25	16	12	0.56
7½	7	0.87	20	9	0.20	17	12	0.50
8	7	0.77				18	12	0.44
10	7	0.49	12	9¼	0.59	18½	12	0.42
12	7	0.34	14	9¼	0.44	20	12	0.36
14	7	0.25	16	9¼	0.33	22	12	0.30
			18½	9¼	0.25	24	12	0.25
			20	9¼	0.21	26	12	0.21

The oil engine selected should have a commercial brake horsepower rating of twice the effective horsepower. Engine and gearing for reduction of speed should be on one base with friction clutch connection to pump shaft.

The power pump, where suction lift is such that the pump can be on same level as engine, may be of the triple single-acting type, or duplex double-acting, direct-connected to engine friction clutch. For small plants the combined engine and pump are recommended.

The power pump in small plants where suction lift is such that the pump must be at a lower level than engine, should be single cylinder, double-acting type, connected to engine by means of a pitman face plate and shaft. In larger plants a two or three cylinder pump with pump head and extension rods, with guides where necessary, will be found more advantageous.

Pump houses should be constructed of non-combustible material wherever practicable. In gasoline plants the engine should be in a separate room, with floor vents. Stoves and lights should not be permitted in gasoline engine rooms. The gasoline supply should be kept outside the house. Where there are deep wells, the house should be so designed that it can be removed or opened to admit of a well machine being placed over it. At terminal stations the pump house should be incorporated with other part of plant where possible.

Each plant should be fitted with a pressure gage on discharge pipe and a revolution counter on pump.

[8] WATER SERVICE RECORDS.

Accurate records of water stations and costs of pumping should be at hand in the office of the official having charge of this branch of the service, and forms M. W. 1301, M. W. 1302, M. W. 1303, M. W. 1304, are recommended for this purpose.

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[8] Adopted, Vol. 10, 1909, pp. 776, 780, 821.

Form M. W. 1301.

PUMPER'S DAILY REPORT.

Railway
Business

ADDRESS OF OFFICIAL

(Folding Line)

INSTRUCTIONS

Each pumper will fill out one of these reports each day for each plant worked at and forward to

(Name of official)

....

In the supply report fill in the column headed "Balance on hand last day of month" only on the report for the last of the month, showing the supplies on hand at the close of the work on the last day of the month.

3 Inches X 3 Inches

PUMPING REPORT

	Hour.	Min.	Hour.	Min.	Hour.	Min.
Time started..						
Time stopped.						
Time ran......						

Counter at start..			
Counter when stopped.			
Dif'rence counter.			
Gage at start..			
Gage when stopped.			
Average gage.....			

(Folding Line)

Pounds Coal used..........................

Gallons Gasoline used..........................

Other Fuel used..........................

STATION..........................

Date..........................19....

Received To-day	Supplies Received	Balance on Hand Last Day of Month
	Kind Tons Coal	
	Gal. Gasoline	
	Qt. Gas Eng. Oil	
	Qt. Cylinder Oil	
	Qt. Car Oil	
	Qt. Oil	
	Lbs. Waste	

Pumper

5½ Inches REPORT SIDE X 5½ Inches ADDRESS SIDE

Size of Card 5½ x 6 inches, printed both sides.

Form M. W. 1302.

STATEMENT OF COST OF PUMPING WATER

STATION	DATE	TIME PUMP RAN		No Rev. of Counter	Gallons Per Rev	GALLONS PUMPED		Gage Press. in Feet	H.P. = Gal. per Min. × Head Feet ÷3960	FUEL REPORTED AS USED			SUPPLIES RECEIVED																COST RECORD INCLUDING LABOR				
													Coal @ $		Gasoline @ $		Other Fuel		Gas Engine Oil @		Cylinder Oil @		Car Oil @		Other Oil @		Waste @						
		Hr.	Min.			Total	Per Min.			Coal Pounds	Gasoline Gallons	Other Fuel	Tons	Cost	Gal.	Cost		Cost	Qts.	Cest	Qts.	Ccst	Qts.	Cest	Qts.	Cost	Lbs.	Cost	Labor Cost	Total Mtl.	Per 1000 Gal.	Per Hour	Per H.P. Hour

Form M. W. 1303.

WATER STATION RECORD

AT ______________________________

WHERE PAINTING RECORD IS DESIRED ENTER DATE PAINTED WITH PREFIX "P" IN DATE COLUMN.

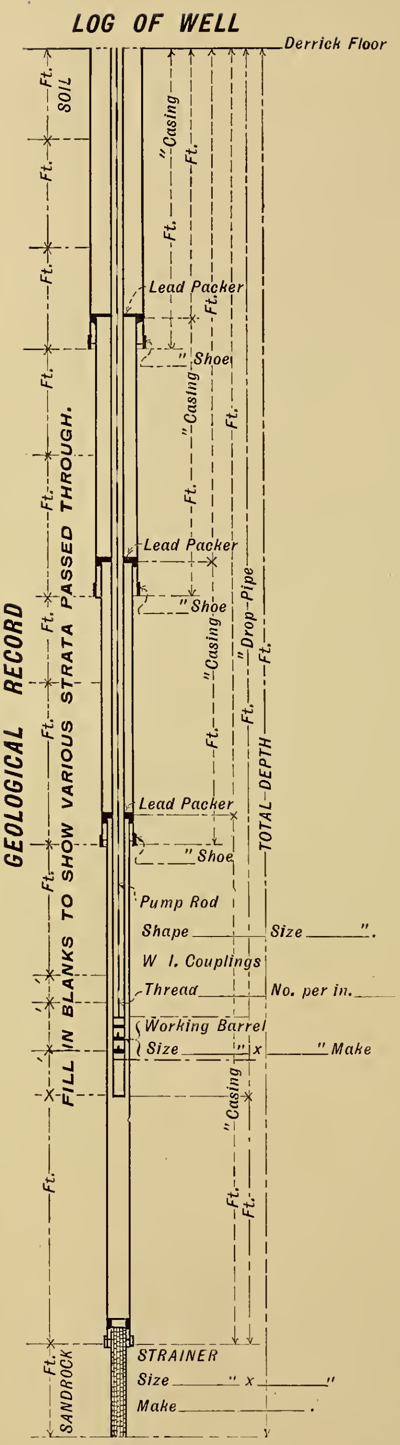
WHERE SECOND-HAND EQUIPMENT IS INSTALLED ENTER DATE OF MANUFACTURE IN BRACKETS OVER INSTALLATION DATE.

WATER TANKS, SETTLING TANKS INCLUDED								WATER COLUMN										PUMP HOUSE							PUMP PIT				WIND MILLS					
Date	Foundation	Substruct.	Tub		Capacity Gallons	Frost Box	Plan Reference	Date	Pit				Column					Date	Width	Length	Sill to Plate	Foundation	Above Found.	Roof	Date	Size	Depth	Material	Tower			Wheel		
			Diam.	Hght.					Width	Lght.	Depth	Matl.	Kind	Col. Diam.	Col. Supply	C.Col. Toc.Tk	Top Rail to Bol. Spout												Date	Kind	Hght.	Date	Kind	Diam.

BOILERS													PUMPS									ENGINES					TREATING PLANTS	
Date Installed	Boiler							Stack			Injector		Date	Maker and Shop Number	Kind of Power	Simplex or Compound Expansion	Single or Double Action	No. of Water Cylinders	Size			Date	Maker and Shop Number	Kind	Rated H.P.	Connections from Engine to Pump	Date	Maker and Plan Reference
	Shop No.	Name Maker	Kind	Shell		Size Grate	No. & Size Flues	Date	Diam.	Height	Size	Kind							Steam	Water	Stroke							
				Lgth.	Diam.																							

WATER SUPPLY														HEIGHTS			ANALYSIS		PIPE LINES SEE ______ FOR LOCATION																			COST RECORD		
Date	Source	Dug Wells			Material	Pipe Wells								Top Tank to			Lbs. incrust. Solids per 1000 gal.	Fitness for Engine Use	Steam			Exhaust			Suction			Discharge			Column Supply			Other Lines				Date	Work Done	Original Construction Cost
		Diam.		Total Depth		Date	Number	Diam.		Total Depth	Working Barrel Below Top Well	Kind Point, Screen or Strainer	Make of Packing Head	High Water	Low Water	Center Pump			Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Use	Length			
		Top	Bottom					Top	Bottom																															

Form M. W. 1304.



RECORD OF DEEP WELLS.

Location ....

Date began drilling....................

Well completed ....

WATER LEVELS.

Water stands at.......................ft.

And pumps down to.................ft.

When delivering .... gals. per minute.

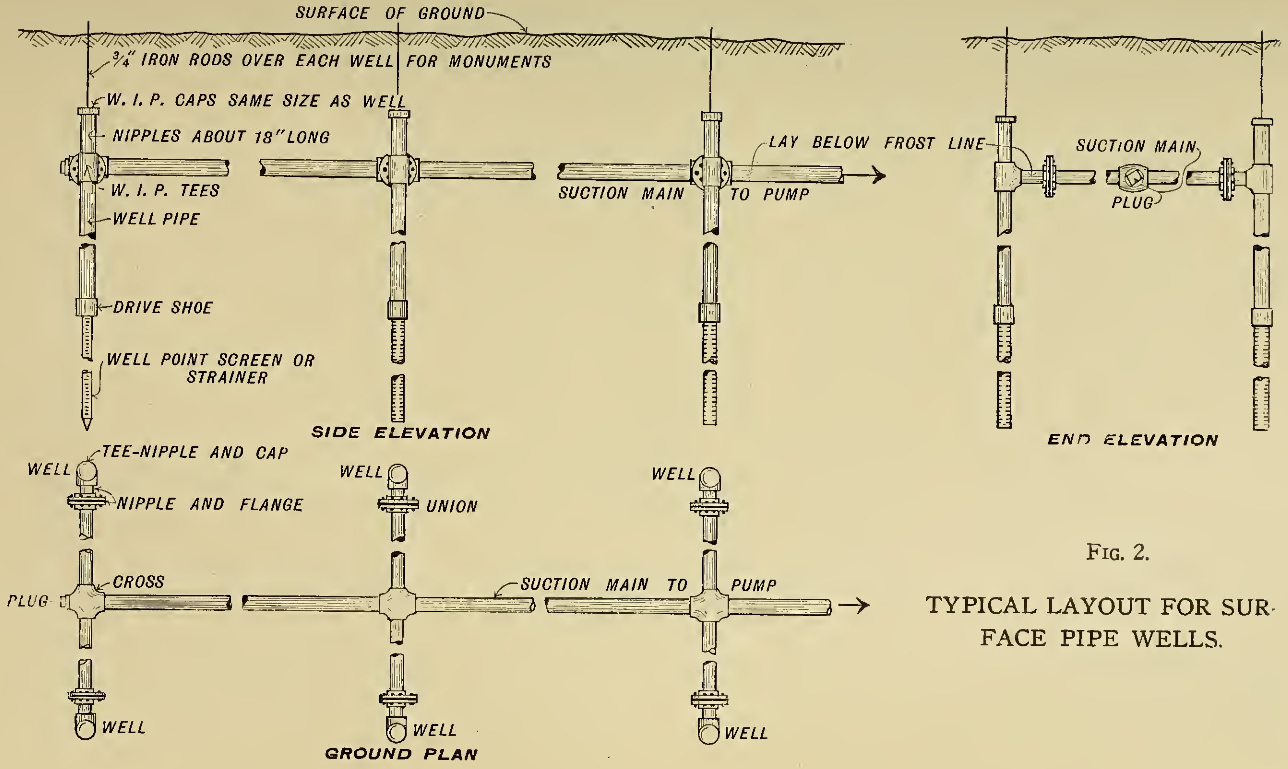


FIG. 2.

TYPICAL LAYOUT FOR SURFACE PIPE WELLS.

[9] GENERAL SPECIFICATIONS FOR STEEL WATER AND OIL TANKS.

Scope of Specifications.

1. These specifications are intended for steel tanks requiring plates not more than ⅝-inch thick.

Quality of Metal.

2. The metal in these tanks shall be open-hearth steel. The steel shall conform in physical and chemical properties to the specifications of this Association for steel bridges.

Loading.

3. The weight of water shall be assumed to be 63 lbs., crude oil 56 lbs., and creosote oil 66 lbs. per cubic foot. Wind pressure, acting in any direction, shall be assumed to be, in pounds, thirty times the product of the height by two-thirds of the diameter of the tank in feet.

Unit Stresses.

4. Unit stresses shall not exceed the following:

   (a) Tension in plates, 15,000 lbs. per square inch on net section.
   (b) Shear in plates, 12,000 lbs. per square inch on net section.
   (c) Shear on rivets, 12,000 lbs. per square inch on net section.
   (d) Bearing pressure on field rivets, 20,000 lbs. per square inch.

Cylindrical Rings.

5. Plates forming the shell of the tank shall be cylindrical and of different diameters, in and out, from course to course.

Workmanship.

6. Workmanship shall be first-class. Plates shall be beveled on all edges for caulking after being punched. The punching shall be from the surface to be in contact. The plates shall be formed cold to exact form after punching and beveling. Rivet holes shall be accurately spaced. Drift pins shall be used only for bringing the parts together. They shall not be driven with enough force to deform the metal about the holes. Power riveting and caulking should be used. A heavy yoke or pneumatic bucker shall be used for power-driven rivets. Riveting shall draw the joints to full and tight bearing.

Caulking.

7. The tank shall be made water or oil tight by caulking only. No foreign substance shall be used in the joints. For water tanks, the caulk-

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[9] Adopted, Vol. 13, 1912, pp. 417-419, 984-988.

ing shall preferably be done on the inside of tank and joint only; but for oil tanks the caulking should be done on both sides. No form of caulking tool or work that injures the abutting plate shall be used.

Minimum Thickness of Plates.

8. The minimum thickness of plates in the cylindrical part of the tank shall be not less than ¼-inch and in flat bottoms not less than 5/16-inch. In curved bottoms the thickness of plate shall be not less than that of the lower plate in the cylindrical part.

Horizontal and Radial Joints.

9. Lap joints shall generally be used for horizontal seams and splices and for radial seams in curved bottoms.

Vertical Joints.

10. For vertical seams and splices, lap joints shall be used with plates not more than ⅜ inch thick. With thicker plates, double butt joints with inside and outside straps shall generally be used. The edge of the plate in contact at the intersection of horizontal and vertical lap joints shall be drawn out to a uniform taper and thin edge.

Rivets, Rivet Holes, Punching and Pitch.

11. For plates not more than ⅜ inch thick, ⅝-inch rivets shall be used. For thicker plates, ¾-inch rivets shall be used. The diameter of rivet holes shall be 1/16-inch larger than the diameter of the rivets used. The punching shall conform to the specifications of this Association for such work on steel bridges. A close pitch, with due regard for thickness of plate and balanced stress between tension on plates and shear on rivets, is desirable for caulking.

Tank Support.

12. If the tank is supported on a steel substructure, the latter shall conform to the specifications of this Association for the manufacture and erection of steel bridges, except that allowance shall be made for wind pressure, but not for impact.

Painting.

13. In the shop the metal shall be cleaned of dirt, rust and scale and, except the surfaces to be in contact in the joints of the tank, shall be given a shop coat of paint or metal preservative selected and applied as specified by the Company.

After being completely erected, caulked and cleaned of dirt, rust and scale, all exposed metal work shall be painted or treated with such coat or coats of paint or metal preservative as shall be selected by the Railway Company.

Plans and Specifications.

14. Under these specifications and in conformity thereto the Railway Company shall cause to be prepared or shall approve detailed plans and specifications for tanks, herein specified, as it shall construct. Such plans and specifications shall cover all necessary tank auxiliaries.

COMMITTEE XIV.

YARDS AND TERMINALS.

[1] DEFINITIONS.

TERMINALS.

Terminal.—An assemblage of facilities provided by a railway at a terminus or at intermediate points on its line for the purpose of assembling, assorting, classifying and relaying trains.

Freight Terminal.—The arrangement of terminal facilities for the handling of freight traffic.

Passenger Terminal.—The arrangement of terminal facilities for the handling of passenger traffic.

YARDS.

Yard.—A system of tracks within defined limits provided for making up trains, storing cars, and other purposes, over which movements not authorized by timetable or by train-order may be made, subject to prescribed signals, rules and regulations.

Receiving Yard.—A yard for receiving trains.

Separating Yard.—A yard adjoining a receiving yard, in which cars are separated according to district, commodity or other required order.

Classification Yard.—A yard in which cars are classified or grouped in accordance with requirements.

Departure or Forwarding Yard.—A yard in which cars are assembled in trains for forwarding.

Storage Yard.—A yard in which cars are held awaiting disposition.

Gravity Yard.—A yard in which the classification of cars is accomplished by gravity.

Coach Yard.—A yard in which passenger train cars are assembled, classified or prepared for service.

Assisting Grade.—The inclination given to tracks of a yard to facilitate the movement of cars.

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[1] Adopted, Vol. 2, 1901, pp. 39, 40, 46-59; Vol. 4, 1903, p. 349; Vol. 5, 1904. pp. 221, 224-226; Vol. 6, 1905, pp. 568-570, 575, 592; Vol. 7, 1906, pp. 153-155; Vol. 11, Part 2, 1910, pp. 1257, 1258, 1309, 1310; Vol. 12, Part 1, 1911, pp. 235. 263; Vol. 16, 1915, pp. 958, 1190.

Poling Yard.—A yard in which the movement of cars is accomplished by the use of a pole operated by an engine on an adjacent parallel track.

Summit or Hump Yard.—A yard in which the movement of cars is accomplished by pushing them over a summit, beyond which they run by gravity.

TRACKS.

Body Track.—Each of the parallel tracks of a yard, upon which cars are switched or stored.

Ladder Track.—A track connecting successively the body tracks of a yard.

Lead Track.—An extended track connecting either end of a yard with the main track.

Interchange Track.—A designated track on which cars are delivered or received, as between railroads.

Drill Track.—A track connecting with the ladder track and used for movements in yard switching.

Running Track.—A track reserved for movement through a yard.

Crossover Track.—A track connecting two adjacent tracks.

Relief Track.—An extended siding long enough to allow an inferior train to continue running.

Stub Track.—A track connected with another one at one end only.

Spur Track.—A stub track of indefinite length diverging from a main line or track.

House Track.—A track alongside of (or entering) a freight house, and used for cars receiving or delivering freight at the house.

Switching District.—That portion of a railway at a large terminal into which cars are moved, and from which they are distributed to the various sidetracks and spurs to freight houses and manufacturing establishments served from this district by yard or switching engines.

Industrial Track.—A track serving one or more industries.

Team Track.—A track where freight is transferred directly between cars and wagons.

Note.—In a typical yard there will be several tracks, devoted to special purposes, varying with local conditions. These will include caboose tracks, scale tracks, coaling tracks, ashpit tracks, bad order tracks, repair tracks, icing tracks, feed tracks, stock tracks, transfer tracks, sand tracks, depressing tracks, etc.

Rail and Water Terminal.—A terminal where freight is transferred between railway cars and boats.

Wye.—A triangular arrangement of tracks used for turning engines, cars or trains.

Transfer Slip.—A protected landing place for transfer boats with adjustable apron or bridge for connecting tracks on the land with those on the transfer boats.

Incline.—An inclined track (or tracks) at a protected landing place, with adjustable apron and cable for connecting to the tracks on a transfer boat.

Siding.—A track auxiliary to main track for meeting or passing trains, limited to the distance between two adjacent telegraph stations.

PIERS.

Lighterage Pier.—An open or covered pier at which freight is transferred directly between cars and boats.

Export Pier.—A pier at which freight is unloaded and stored, mainly for shipment on ocean or coasting vessels.

Station Pier.—A pier having no rail connections, where freight is received and delivered by transfer boats.

Coal Pier.—An open pier where coal is transferred from cars to vessels or barges.

[2] GENERAL REQUIREMENTS OF YARDS AND TERMINALS.

Body Tracks.

Under ordinary conditions body tracks should be spaced 13 feet to 14 feet center to center, and where they are parallel to main track or other important running track, the first body track should be spaced not less than 15 feet center to center from such main or other important track.

Ladder Tracks.

These should be spaced not less than 15 feet center to center from any parallel track. Frogs of greater angle than No. 8 should not be generally used, and the angle between the ladder track and body tracks will be governed by the distance on ladder track required for a turnout.

Lead Tracks.

To facilitate train movements the connections of these tracks with the main track should be interlocked. To facilitate and protect train movements means of direct communication should be established.

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[2] Adopted, Vol. 2, 1901, pp. 43-45; Vol. 3, 1902, pp. 267, 268, 280-288; Vol. 4, 1903, pp. 370-380; Vol. 5, 1904, pp. 182-184, 221-224; Vol. 6, 1905, pp. 570-574, 583, 592-594; Vol. 11, Part 2, 1910, pp. 1258, 1259, 1309; Vol. 12, Part 1, 1911, pp. 236, 264; Vol. 16, 1915, pp. 958, 1190.

Drill Tracks.

Drill tracks should be so located as to cause least possible interference with other movements.

Running Tracks.

Running tracks should be provided for movements in either direction to enable yard engines to pass freely from one position of the yard to the other; also to enable road and yard engines to pass to and from the engine house and other points where facilities are provided.

Crossover Tracks.

Crossover tracks should be located at most convenient points where they will least interfere with regular movements.

Caboose Tracks.

Where conditions permit, caboose tracks should be so located that cabooses can be placed on and removed from them in the order of their arrival, and should be so constructed that cabooses can be dropped by gravity onto the rear of trains made up for departure.

Scale Tracks.

Scale tracks should be so located that weighing can be done with least delay and without drilling over scale. Where many cars are to be weighed they should pass separately over the scale by gravity, being weighed while in motion.

Coaling, Ashpit, Sand and Engine Tracks.

These tracks should be located on the route leading to and from the engine house and should provide sufficient storage for the reception of engines by the hostler. They should be so arranged that water, coal and sand can be taken and ashes disposed of in convenient rotation, and that switching engines may clean fires, take coal, water and sand and pass around waiting engines.

Bad-Order Tracks.

Where cars are classified, one or more classification tracks, easy of access, should be provided for setting off cars in bad order, from which they may be readily removed to the repair tracks.

Repair Tracks.

These tracks should preferably be connected at both ends and have a maximum capacity of about 15 cars each, spaced alternately 16 feet and 24 feet center to center and be connected conveniently to bad-order tracks.

Icing Tracks.

Icing tracks should be so located that the work of shifting out, icing and classifying cars for movement can be performed in least time.

Yard.

If possible to so arrange, the main tracks of both single and double track roads should be located on the outside of yard, and the engine house, coaling station, etc., should be centrally located.

Coach Cleaning Yard.

The coach cleaning yard should be located near the terminal station. The tracks should be of sufficient length to hold full trains, with a car cleaners' repair and supply building adjacent thereto.

Inbound Freight House.

Inbound freight house should be of such width as will furnish a reasonable amount of floor space for holding freight (50 feet is a good average width). Usually not more than two tracks are needed, and the side toward the tracks should be provided with a platform and should be fitted with continuous doors to avoid the necessity for spotting cars.

Outbound Freight House.

The outbound freight house should be narrow (30 feet is a good average width) and usually not more than four to six tracks should be provided. The side toward the tracks should have a platform or continuous doors.

Where a great number of cars are required, the average trucking distance will generally be least, and trucking through cars will be avoided if the freight house is built at right angles to and at the back ends of a series of tracks built in pairs with covered platforms between.

Roadways.

Where the freight house is on one side and a wall on the other, the minimum width of roadway should be 30 feet; but where a freight house is on one side and a team track or another freight house is on the other, the minimum clear width of roadway should be 40 feet.

Transfer Station.

A transfer station should be located at a point where traffic is concentrated and where a necessity exists for consolidating freight into a less number of cars for movement to a certain destination, or for separating and reloading freight into a greater number of cars or into system cars for further movement to final delivery.

Yard at Rail and Water Terminals.

The tracks should be so arranged that as trains arrive the cars can be promptly classified and grouped for delivery without interference with other movements.

Piers.

At rail and water terminals the piers should be designed with a view to the most efficient, rapid and economical handling of the business; and with a view to its future development. Care must be taken to give due weight to the special conditions and features of location, traffic, etc, which are peculiar to each case, and which render it impossible to lay down any but the most general rules.

In every individual case the length, width, number of tracks, width of platforms, details of construction and width of waterway between adjacent piers must be adjusted to best meet conditions as to shape and area of site as well as its relation to its approach from both land and water, the character and volume of business and the manner in which it is to be handled.

Covered Lighterage Pier.

When conditions will permit, present practice will generally suggest a length of approximately 600 feet with two depressed tracks. If the business to be handled over the pier is expected to move quickly the width should be no greater than is necessary to provide temporary storage and shelter for the goods during ordinary detentions while waiting for cars or lighters, preferably about 100 feet. If the movement is expected to be slow and it is necessary to provide storage while waiting for cars or vessels, or for assorting, classifying, inspecting or sale of goods, the width should be increased, but generally not beyond a width of 125 to 160 feet. If the movement is not expected to have a special charatcer, or a mixed business is to be provided for, a compromise width of 125 feet is suggested. The space between the shed and the outer edge of the pier should be not less than two feet. The clear width of waterway between piers should be, if possible, not less than four times the width of the largest vessel to be handled.

Open Lighterage Pier.

This should, if possible, have a length of about 600 feet and the width, number of tracks and the appliances for handling traffic should be adjusted to the particular use to which the pier is to be applied. Crossovers may be necessary on long piers.

For ordinary coarse freight in bulk, such as iron ore, stone, timber and similar products, the width should be from 50 to 80 feet, and there should be four tracks, with crossovers, to facilitate the handling of cars and to avoid delay in transferring to or from vessels. If the business is light, or consists principally of heavy or costly products, such as cut stone, machinery, or miscellaneous freight not requiring shelter, a narrow pier of about 35 feet in width, with two tracks only, is recommended.

Export and Storage Pier.

This should be designed with special reference to the character of the commodities to be handled; whether quick movement is expected or the goods are to be held some time in storage for the accumulation of full cargoes, or for inspection or classification. There should be two tracks in a depressed pit on the pier level, and on long piers these should be connected by crossovers at convenient intervals to facilitate the movement of cars. On very wide piers additional tracks on the pier level are desirable under certain conditions.

Where the water front is limited or very valuable and the conditions, volume and character of business warrant, pier sheds of two or more stories, with platform or barrel elevators and bag or barrel chutes, are used. Under certain conditions additional tracks in the second story may prove more advantageous than elevators.

The length should be sufficient to properly accommodate either one or two vessels on each side at the same time or approximately 600 to 1400 feet. The width must be determined by the space available and the business to be handled. If quick moving, a width of 125 to 150 feet is recommended. If slow moving and large accumulations must be received and stored, the width may be extended, if space permits, to 300 or even 400 feet, but excessive width is not recommended on account of the consequent increase in cost of handling. The space between shed and face of pier should be not less than three nor more than six feet. The clear waterway between piers should be, if possible, not less than four times the width of the largest vessels to be handled.

Coal Pier.

This should be an open pier, and where coal is to be delivered to vessels through pockets and chutes in the ordinary way, the pier should be high enough to allow coal from drop-bottom cars to be loaded by gravity into vessels or barges. It should have three or more tracks, the outside tracks for loaded cars and the inside one on an incline to return the empty cars to the yard by gravity. The length depends upon the grade necessary to reach the desired elevation, the length of the vessel to be coaled and the number of cars it is desired to unload at one time. Adjacent piers should be sufficiently distant to accommodate the class of service, which will depend on the length of the pier and the size of the water craft to be accommodated. Where coal cars are dumped by machinery which elevates and tilts the cars a high pier is not necessary, and it may be of any convenient height.

Station Pier.

A city station pier served by car floats should be approximately 600 feet long and 125 feet wide, with a depressed driveway in the center 35 feet wide. It should be a closed pier, with a 3-foot platform outside. Adjacent parallel piers should be, if possible, 200 feet apart in the clear. Along the water street should be a bulkhead, approximately 55 feet wide, with two-story building, the upper floor being for offices, fruit auction room, etc.

Grain Elevators.

If conditions permit, grain elevators should be so located that cars may be put in at one end and taken out at the other, and without interference with other yard movements. Where this cannot be done, the tracks should be so arranged that the work of placing and removing cars may be done without serious interference with the operation of the elevator or delay to other shifting.

[3] CAR CAPACITY OF FREIGHT TRACKS.

(1) It is recommended that 42 feet per car be allowed in rating the car capacity of freight tracks.

(2) Freight car repair yards should be composed of short tracks of about fifteen cars capacity, arranged in pairs. Each pair should be spaced 16 feet center to center of tracks and the pairs should be spaced 40 feet center to center of pairs.

(3) A material supply track should be placed in the space between each pair of tracks.

(4) In computing working capacity of repair tracks 50 feet should be allowed for each car.

(5) The yard should be equipped with air and water pipes, and outlets furnished with air hose should be provided at intervals of 50 feet for testing the brakes on cars.

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[3] Adopted, Vol. 6, 1905, pp. 579, 594; Vol. 11, Part 2, 1910, pp. 1262, 1263, 1309; Vol. 16, 1915, pp. 958, 1190.

(6) Tracks on which heavy repairs to freight cars are made should be under cover and cranes provided for heavy lifting.

[4] TEAM DELIVERY YARDS.

(1) Team delivery yards should be located convenient to the freight house, so that the receipt and shipment of freight may be easily under control of the freight agent's force.

(2) The tracks should be stub tracks arranged in pairs spaced 12 feet center to center, and if conditions permit the pairs should be spaced not less than 52 feet center to center of pairs, or 30 feet in clear. For convenience in handling, the tracks should not exceed 20 cars capacity each.

(3) If necessary, the yard should be provided with a crane for handling heavy freight.

(4) Ingress and egress for teams should be provided at each end of each teamway if possible.

(5) Wagon scales if installed should be at the most convenient place near the entrance to the driveway.

[5] HUMP YARDS.

(1) Hump yards should consist of receiving, classification and departure tracks in consecutive order.

(2) A hump yard is a desirable form of yard for receiving, classifying and making up trains, because a greater number of classifications can be made in less time and at less cost than through any other form of yard.

(3) Receiving tracks should be of sufficient length to hold maximum trains of the various classes handled.

(4) Receiving tracks should be sufficient in number to hold a number of trains arriving in quick succession. The number will depend on the amount and character of traffic handled, and upon the relative location of the yard with respect to the other yards and connections.

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[4] Adopted, Vol. 7, 1906, pp. 155, 156, 171; Vol. 11, Part 2, 1910, pp. 1263, 1309; Vol. 16, 1915, pp. 958, 1191.

[5] Adopted, Vol. 7, 1906, pp. 142, 143, 168-170, 173-179; Vol. 11, Part 2, 1910, pp. 1263, 1264, 1309; Vol. 14, 1913, pp. 936, 937, 1095-1099; Vol. 16, 1915, pp. 959, 1191.

(5) If it is possible, the grades of the receiving tracks should be such that one engine can push the maximum train over the hump.

(6) No definite recommendation can be made as to length or number of classification tracks, except that when they are to be used as departure tracks they should be long enough to hold full trains; and that when conditions permit there should be as many of them as can be used to advantage to avoid subsequent classification and consequent delay.

(7) Departure tracks should be full train length and of sufficient number to provide ample standing room for trains while being tested for air, and while waiting for engines.

A rider track should, if possible, be provided through center of classification yard, running to summit of hump, independent of other yard movements. This will avoid hazard of personal injury to car riders and reduce the number of car riders to a minimum.

(8) An air-brake testing plant should be provided in the reciving and departure yards. Pipes should be laid along the tracks, and sufficient outlets furnished (with hose) to test air brakes on all trains.

(9) To secure the greatest possible efficiency or to so construct a hump that the greatest number of cuts of cars may be classified over it, the steepest part of the grade should be reached in the least available distance after passing the summit and the grade or fall should provide sufficient momentum to carry all cars to the lower ends of classification tracks.

(10) Where cars to be classified are largely empty or light, and the scale is on the hump, grades are recommended for average conditions as follows:

The summit of the hump should be reached from the ascending grade by vertical curves with radius of about 1500 feet that raise the grade about one foot in a distance of 60 feet. The curve over the summit to be continued on the descending grade a distance of about 30 feet to join a grade not exceeding 2 per cent. for a distance not exceeding 60 feet; thence descending by a vertical curve with a radius of about 2000 feet, a distance of 40 feet; thence descending on a grade of 4 per cent., a distance of 50 feet; thence descending by a vertical curve with a radius of about 5000 feet, a distane of about 155 feet, to join a grade of 1 per cent. at the heads of the ladder tracks; thence down through ladder tracks and turnouts, 1 per cent.; thence down through classification tracks, 0.5 per cent.

(11) Where cars to be classified are largely heavy or loaded, and the scale is on the hump, the same grades are recommended for use over the hump as for light cars, but as the proportion of light cars diminishes the length of the grade of 4 per cent. may be reduced.

It is recommended, however, that the length of the 4 per cent. grade be at least 30 feet; that the grade of ladder tracks be at least 0.8 per cent., and the grade of classification tracks be at least 0.5 per cent., where conditions permit.

(12) Where traffic or climatic conditions require, the summit of a hump may be made higher in the winter and restored when the increased height is not needed.

(13) When required by traffic conditions, a track scale not exceeding 60 feet in length should be located at such a distance from the summit of the hump that when cars to be weighed reach the scale they will be properly spaced from following cars and will be running slowly enough to easily secure correct weights. The grade over the scale should not exceed 2 per cent.

(14) For average conditions it is recommended that No. 8 frog be the sharpest used in classification yards.

(15) Where tracks are set aside for holding empty cars, the grade leading to such empty track should be increased so that empty cars will move with the same velocity as loaded cars switched to adjoining tracks.

(16) The cut list system of handling cars on the hump is recommended as being efficient; it is briefly described as follows: The yard clerk makes up a list of cars to be switched and tracks they are to be placed on in receiving yard, cut No. 1 being the first car to go over the hump. (See cut list on following page.) It is perforated on vertical lines, so that it may be divided into multiple parts, each part being a duplicate of the other.

Where switches are thrown from a tower, one copy of the list is given to the towerman and one to the man cutting off cars on the hump.

Where switches are thrown by hand, each switchtender has a copy of the cut list, as well as the man cutting off cars on the hump.

Cut List

No. of Cut	No. of Track	Cars In Cu
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Cut List

No. of Track	Cars In Cut

Cut List

No. of Track	Cars In Cut

Cut List

No. of Track	Cars In Cut

[6] YARD LIGHTING.

(1) For yard lighting the use of nitrogen lights of 1500 watts capacity, equivalent to about 2200 candlepower, is recommended.

(2) For lighting hump and ladder tracks, the lamps should be spaced 140 to 150 feet apart and hung 28 feet (or more) above the tracks.

(3) For lighting body tracks, the spacing should be such that cars will be clearly visible.

[7] FREIGHT TRANSFER STATIONS.

(1) Freight transfer stations should be located at points where traffic converges or diverges, or both, and where necessity exists for its consolidation or separation.

(2) The installation should provide for the greatest possible economy of operation both as to time and cost of handling.

(3) Where fixed platforms are used, they should be covered, and it is recommended that the width under ordinary conditions be not more than 24 feet, and that the tracks on either side be built in pairs. If greater facilities are required, additional platforms 8 feet in width may be provided outside of the first two tracks and additional tracks placed outside of them. The width of these additional platforms may be 8 feet, if without roofs, or 12 feet, if covered by roofs, supported by a line of posts in the middle.

(4) Where large amounts of freight are to be transferred, the use of power-driven covered traveling platforms instead of fixed platforms is suggested.

[8] PASSENGER TERMINAL STATIONS.

(1) To avoid excessive cost in providing passenger terminal facilities largely in excess of ordinary requirements, it is imperative that provision be made for economical, efficient and practically continuous operation of the terminal during the periods of greatest activity which may

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[6] Adopted, Vol. 9, 1908, pp. 541, 584; Vol. 11, Part 2, 1910, pp. 1264, 1309; Vol. 16, 1915, pp. 959, 1191.

[7] Adopted, Vol. 7, 1906, pp. 155, 170; Vol. 11, Part 2, 1910, pp. 1264, 1265, 1309; Vol. 16, 1915, pp. 959, 1191.

[8] Adopted, Vol. 12, Part 1, 1911, pp. 240, 268; Vol. 14, 1913, pp. 924, 1090-1095.

reasonably be expected within a period of, say, twenty years. To this end the track layout must be designed to permit incoming and outgoing movements to be made at the same time without interference, as far as it is possible to arrange this.

(2) At passenger terminals where large quantities of baggage and express must be handled, and it does not appear expedient to provide intermediate platforms to be used exclusively for this service, it is recommended that (where conditions permit), baggage and express be received, delivered and handled below the train floor; and raised and lowered by elevators, conveniently located, to avoid interference with the movement of passengers.

(3) A holding yard should be directly connected with the platform tracks to provide for a quick emptying and refilling of the latter.

(4) Where practicable, on station throat tracks the curvature through switches should not exceed that of a No. 8 slip on tangents.

[9] TYPICAL SITUATION PLANS FOR DIVISION ENGINE TERMINAL.

(1) The engine terminal should be so located as to afford easy access to both main line and yards, with the fewest possible reverse or conflicting movements.

(2) The facilities provided should be arranged to permit of the most direct and rapid handling of an engine in its terminal in the order of its needs.

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[9] Adopted, Vol. 13, 1912, pp. 93, 947-948.

COMMITTEE XV.

IRON AND STEEL STRUCTURES.

[1] CONTRACTING FOR STEEL RAILWAY BRIDGES.

It is recommended that railway companies

(1) Furnish general detailed plans and specifications of structural work to bidders, complete enough to show the exact character of the work. If such plans cannot be furnished, the alternative should be full specifications, accompanied by outline plans and complete information concerning the work.

(2) Invite bids on a pound price basis. If desired, alternate bids may be asked for the work, f. o. b. cars, and for the work erected. A lump sum bid is inadmissible unless general detailed plans and specifications are furnished.

(3) Invite bids for as large groups of bridges as can be defined consistently with the first recommendation. When necessary to anticipate future requirements, the railway company need not submit designs if the nature of the work is known to the bidder by reason of similar work previously performed by him for the railway, or if designs of similar structures are submitted to the bidders.

(4) Erect bridges with their own forces on lines where traffic is to be maintained. On small railways where suitably organized and equipped forces for such work may not be justified, the large bridges, and in some cases all bridges, may be erected by contract.

(5) Furnish and lay the floor timber in all cases.

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[1] Adopted, Vol. 7, 1906, pp. 184, 263, 264; Vol. 11, Part 1, 1910, pp. 115, 160.

[2] GENERAL SPECIFICATIONS FOR STEEL RAILWAY BRIDGES.

Part First—Design.

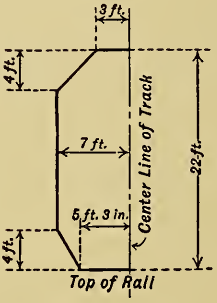
(1) GENERAL.

Materials.

1. The material in the superstructure shall be structural steel, except as otherwise specified.

Clearances.

2. If the alinement is straight, clearances shall be not less than shown on the diagram. If the alinement is curved, the width of the diagram shall be increased so as to provide the same minimum clearances for a car 80 feet long, 14 feet high and 60 feet center to center of trucks, allowance being made for curvature and superelevation of rails. The height of rail shall be assumed as 6 inches.



Spacing Trusses.

3. The width center to center of girders and trusses shall be not less than one-twentieth of the effective span, and not less than is necessary to prevent overturning under the assumed lateral loading.

Skew Bridges.

4. In skew bridges without ballasted floors, the ends of girders and beams supporting the track shall be square with the track at the abutments.

Floors.

5. Wooden tie floors shall be secured to the stringers and shall be proportioned to carry the maximum wheel load, with 100 per cent. impact, distributed over three ties, with fiber stress not to exceed 2000 lbs. per square inch. Ties shall be not less than 10 feet in length. They shall be spaced with not more than 6-inch openings, and shall be secured against bunching.

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[2] Adopted, Vol. 4, 1903, pp. 130-137, 141, 142, 253-279; Vol. 5, 1904, pp. 581-583; Vol. 6, 1905, pp. 228-237, 239, 448-455, 481; Vol. 7, 1906, pp. 185-207, 236-263; Vol. 11, Part 1, 1910, pp. 115-125, 160-167.

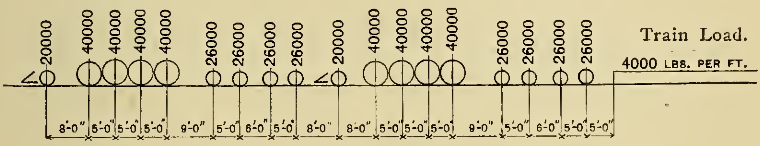
(2) LOADS.

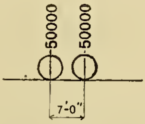
Dead Load.

6. The dead load shall consist of the estimated weight of the entire suspended structure. Timber shall be assumed to weigh 4½ lbs. per foot B. M.; ballast 100 lbs. per cubic foot, reinforced concrete 150 lbs. per cubic foot, and rails and fastenings, 150 lbs. per linear foot of track.

Live Load.

*7. The live load, for each track, shall consist of two typcial engines followed by a uniform load, according to Cooper's series, or a system of loading giving practically equivalent stresses. The minimum loading shall be Cooper's E-40, as shown in the following diagrams:





The diagram that gives the larger stresses shall be used.

Heavier Loadings.

8. Heavier loadings shall be proportional to the above loadings with the same wheel spacing.

Impact.

9. The dynamic increment of the live load shall be added to the maximum computed live load stresses and shall be determined by the formula $I = S \frac{300}{L + 300}$

where I = impact or dynamic increment to be added to live load stresses.

S = computed maximum live-load stress.

L = length of track in feet loaded to produce the maximum stress in the member. For bridges carrying more than one track, the aggregate length of all tracks loaded to produce the stress shall be used.

Impact shall not be added to stresses produced by longitudinal, centrifugal and lateral or wind forces.

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* See Addendum, clause (a).

Lateral Forces.

10. All spans shall be designed for a lateral force on the loaded chord of 200 lbs. per linear foot plus 10 per cent. of the specified train load on one track, and 200 lbs. per linear foot on the unloaded chord; these forces being considered as moving.

Wind Force.

11. Viaduct towers shall be designed for that one of the following loads, considered as moving, which gives the greater stress:

(a) A force of 50 lbs. per square foot applied on one and one-half times the vertical projection of the tower and the portion of the structure which it supports.

(b) A force of 30 lbs. per square foot, applied on the same surface, plus 400 lbs. per linear foot of structure applied 7 feet above the top of the rail, for assumed wind force on train, when the structure is loaded, on either one or both tracks, with empty cars weighing 1200 lbs. per linear foot.

Longitudinal Force.

12. Viaduct towers and similar structures shall be designed for a longitudinal force of 20 per cent. of the live load applied at the top of the rail.

13. Structures on curves shall be designed for the centrifugal force of the live load applied at the top of the high rail. The centrifugal force shall be considered as live load and shall be derived from the speed in miles per hour given by the expression $60-2\frac{1}{2}D$, in which "D" = degree of curve.

(3) UNIT STRESSES AND PROPORTION OF PARTS.

Unit Stresses.

14. Structures shall be so proportioned that the sum of the maximum stresses produced by the foregoing loads will not exceed the following amounts in pounds per square inch, except as modified in paragraphs 22 to 25:

Tension.

15. Axial tension on net section........................16,000

Compression.

16. Axial compression on gross section of columns.....$16{,}000-70\frac{l}{r}$

with a maximum of 14,000

where "l" is the length of the member in inches, and "r" is the least radius of gyration in inches.

Direct compression on steel castings..........................16,000

Bending.

17. Bending: on extreme fibers of rolled shapes, built sections, girders and steel castings; net section..............16,000
on extreme fibers of pins....................................24,000

Shearing.

18. Shearing: shop driven rivets and pins............12,000
field driven rivets and turned bolts..........................10,000
plate girder webs; gross section............................10,000

Bearing.

19. Bearing: shop driven rivets and pins..............24,000
field driven rivets and turned bolts..........................20,000
expansion rollers; per linear inch.......................... 600 *d*
where *"d"* is the diameter of the roller in inches.
on masonry 600

Limiting Length of Members.

20. The ratio of length to least radius of gyration shall not exceed 100 for main compression members nor 120 for wind and sway bracing.

21. The lengths of riveted tension members in horizontal or inclined positions shall not exceed 200 times their radius of gyration about the horizontal axis. The horizontal projection of the unsupported portion of the member shall be considered its effective length.

Alternate Stresses.

22. Members subject to alternate stresses of tension and compression shall be proportioned for the kind of stress requiring the larger section. If the alternate stresses occur in succession during the passage of one train, as in stiff counters, each stress shall be increased by 50 per cent. of the smaller. The connections of such members shall in all cases be proportioned for the sum of the stresses so increased.

23. If the live load and dead load stresses are opposite in character, only two-thirds of the dead load stress shall be considered as effective in counteracting the live load stress. This reduction of dead load shall not be made in proportioning members subject to alternate stresses.

Combined Stresses.

24. Members subject to both axial and bending stresses shall be proportioned so that the combined fiber stresses will not exceed the allowed axial stress.

25. Members subject to stresses produced by combinations of lateral, longitudinal, and wind forces with dead load, live load, impact, and cen-

trifugal force, may be proportioned for unit stresses 25 per cent. greater than those specified in paragraphs 15 to 19, inclusive; but the section shall be not less than that required for dead load, live load, impact, and centrifugal force.

Net Section at Rivets.

26. In proportioning tension members the diameter of the rivet holes shall be taken $\frac{1}{8}$ inch larger than the nominal diameter of the rivet.

Rivets.

27. In proportioning rivets the nominal diameter of the rivet shall be used.

Net Section at Pins.

28. The minimum net section through the pin-hole of pin-connected riveted tension members shall be at least 25 per cent. in excess of the net section of the body of the member. The minimum net section back of the pin-hole, parallel with the axis of the member, shall be not less than the net section of the body of the member.

Plate Girders.

29. Plate girders shall be proportioned either by the moment of inertia of their net section; or by assuming that the flanges are concentrated at their centers of gravity. In the latter case one-eighth of the gross section of the web, if properly spliced, may be used as flange section. The thickness of web plates shall be not less than 1/160 of the unsupported distance between flange angles (see 38).

Compression Flange.

30. The gross section of the compression flanges of plate girders shall be not less than the gross section of the tension flanges. If the compression flange of any beam or girder consists of angles only or if the cover consists of flat plates, the stress per square inch shall not exceed $16{,}000 - 200\frac{l}{b}$. If the cover consists of a channel section the stress per square inch shall not exceed $16{,}000 - 150\frac{l}{b}$. *L* represents the length of unsupported flange, and *b* is the flange width.

Flange Rivets.

31. The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer in a distance equal to the effective depth of the girder at any given point, the total shear at that point combined with any load that is applied directly on the flange. If the ties rest

on the flanges, each wheel load shall be assumed to be distributed over three ties.

Depth Ratios.

32. The depth of trusses shall preferably be not less than one-tenth of the span. The depth of plate girders and rolled beams, used as girders, shall preferably be not less than one-twelfth of the span. If shallower trusses, girders or beams are used, the section shall be increased so that the maximum deflection will not be greater than if the above limiting ratios had not been exceeded.

(4) DETAILS OF DESIGN.

GENERAL REQUIREMENTS.

Open Sections.

33. Structures shall be so designed that all parts will be accessible for inspection, cleaning and painting.

Pockets.

34. Pockets or depressions which would hold water shall be provided with drain holes, or be filled with waterproof material.

Symmetrical Sections.

35. Main members shall be so designed that the neutral axis will be as nearly as practicable in the center of the section. The neutral axes of intersecting main members of trusses shall meet at a common point.

Counters.

36. Rigid counters are preferred. If subject to reversal of stress the chord connections shall preferably be riveted. Adjustable counters shall have open turnbuckles.

Strength of Connections.

37. The strength of connections shall be sufficient to develop the full capacity of the member for the kind of stress it is to carry even though the computed stress is less than such capacity.

Minimum Thickness.

38. The minimum thickness of metal shall be ⅜ inch, except for fillers.

Pitch of Rivets.

39. The minimum distance between centers of rivet holes shall be three diameters of the rivet; but the distance shall be preferably not less than 3 inches for ⅞-inch rivets and 2½ inches for ¾-inch rivets. The

maximum pitch in the line of stress for members composed of plates and shapes shall be 6 inches for ⅞-inch rivets and 5 inches for ¾-inch rivets. For angles with two gage lines and rivets staggered the maximum pitch in each line shall be twice the above. If two or more plates are used in contact, rivets not more than 12 inches apart in either direction shall be used to hold the plates together. In tension members composed of two angles in contact, a pitch of 12 inches may be used for riveting these angles together.

Edge Distance.

40. The minimum distance from the center of any rivet hole to a sheared edge shall be 1½ inches for ⅞-inch rivets and 1¼ inches for ¾-inch rivets, and to a rolled edge 1¼ inches and 1⅛ inches, respectively. The maximum distance from any edge shall be eight times the thickness of the plate, but shall not exceed 6 inches.

Maximum Diameter.

41. The diameter of the rivets in any angle whose size is determined by calculated stress shall not exceed one-fourth of the width of the leg in which they are driven; in angles whose size is not so determined ⅞-inch rivets may be used in 3-inch legs, and ¾-inch rivets in 2½-inch legs.

Long Rivets.

42. Rivets carrying calculated stress and whose grip exceeds four diameters shall be increased in number at least one per cent. for each additional $\frac{1}{16}$-inch of grip.

Pitch at Ends.

43. The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivets, for a distance equal to one and one-half times the maximum width of member.

Compression Members.

44. In built compression members the metal shall be concentrated in the webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between the lines of rivets, connecting it to the flanges. The thickness of cover plates shall be not less than one-fortieth of the distance between the nearest rivet lines.

Minimum Angles.

45. The minimum thickness of flange angles of girders and built members without cover plates shall be one-twelfth of the width of the outstanding leg.

Tie Plates.

46. The open sides of compression members shall be provided with lacing bars and shall have tie plates as near each end as practicable. Tie plates shall be provided at intermediate points where the lacing is interrupted. In main members the length of end tie plates shall be not less than the distance between the nearest lines of rivets connecting them to the flanges, and the length of intermediate tie plates not less than one-half that distance. Their thickness shall be not less than one-fiftieth of the same distance.

Lacing.

47. The lacing of compression members shall be proportioned to resist the shearing stresses corresponding to the allowance for flexure for uniform load provided in the column formula in paragraph 16 by the term $70\frac{l}{r}$. The minimum width of lacing bars shall be 2½ inches for ⅞-inch rivets, 2¼ inches for ¾-inch rivets, and 2 inches for ⅝-inch rivets if used. The thickness shall be not less than one-fortieth of the distance between end rivets for single lacing, and one-sixtieth for double lacing. Shapes of equivalent strength may be used instead of bars.

48. Five-eighths-inch rivets shall be used for lacing flanges less than 2½ inches wide, ¾-inch rivets for flanges from 2½ to 3½ inches wide, and ⅞-inch rivets for flanges 3½ inches and over in width. Lacing bars with at least two rivets in each end shall be used for flanges over 5 inches wide.

49. The inclination of lacing bars with the axis of the member shall be not less than 45 degrees. If the distance between rivet lines in the flanges is more than 15 inches, and a single rivet bar is used, the lacing shall be double and riveted at the intersections.

50. Lacing bars shall be so spaced that the portion of the flange included between their connections will be as strong as the member as a whole.

Faced Joints.

51. Abutting joints in compression members faced for bearing shall be sufficiently spliced on four sides to hold the connecting members accurately in place. Other joints in riveted work, whether in tension or compression, shall be fully spliced.

Pin Plates.

52. Pin-holes shall be reinforced by plates if necessary, and at least one plate shall be as wide as the flanges will allow, and be on the same

side as the angles. Pin plates shall contain sufficient rivets to distribute their portion of the pin pressure to the full cross-section of the member.

Forked Ends.

53. The ends of compression members shall not be forked unless unavoidable; with forked ends, a sufficient number of pin plates shall be provided to give the jaws twice the sectional area of the member. At least one of these plates shall extend to the far edge of the farthest tie plate, and the others to the far edge of the nearest tie plate, but not less than 6 inches beyond the near edge of the farthest tie plate.

Pins.

54. Pins shall be long enough to insure a full bearing of all the parts connected upon the turned body of the pin. They shall be secured by chambered nuts or be provided with washers if solid nuts are used. The screw ends shall be long enough to admit of burring the threads.

55. Pin connected members shall be held against lateral movement on the pins.

Bolts.

56. Where members are connected by bolts, the turned bodies of the bolts shall be long enough to extend through the metal. A washer at least ¼ inch thick shall be used under the nut. Bolts shall not be used in place of rivets except by special permission. Heads and nuts shall be hexagonal.

Indirect Splices.

57. If splice plates are not in direct contact with the parts which they connect, rivets shall be used on each side of the joint in excess of the number required in the case of direct contact to the extent of one-third of that number for each intervening plate.

Fillers.

58. Where rivets carrying stress pass through fillers the fillers shall be extended beyond the connected member and the extension secured by additional rivets equal in number to 50 per cent. of those required to carry the stress.

Expansion.

59. Provision shall be made for expansion and contraction in all bridge structures to the extent of ⅛ inch for each ten feet of length. Means shall be provided to prevent excessive motion at any point.

Expansion Bearings.

60. Spans of 80 feet and over resting on masonry shall have turned rollers or rockers at one end. Spans of less length shall be arranged to slide on smooth surfaces. These expansion bearings shall be designed to permit motion in one direction only.

Fixed Bearings.

61. Fixed bearings shall be firmly anchored to the supports.

Rollers.

62. Expansion rollers shall be not less than 6 inches in diameter. They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be readily cleaned. Segmental rollers shall be geared to the upper and lower plates.

Bolsters.

63. Bolsters or shoes shall be so constructed that the load will be distributed uniformly over the entire bearing. Spans of 80 feet and over shall have hinged bolsters at each end.

Wall Plates.

64. Wall plates may be cast or built up and shall be so designed as to distribute the load uniformly over the entire bearing. They shall be secured against displacement.

Anchorage.

65. Anchor bolts for viaduct towers and similar structures shall be designed to engage a mass of masonry the weight of which is at least one and one-half times the uplift.

Inclined Bearings.

66. The sole plates of bridges on an inclined grade without pin shoes shall be beveled so that the masonry and expansion surfaces will be level.

FLOOR SYSTEMS.

Floor Beams.

67. Floor beams shall preferably be square to the girders or trusses. They shall be riveted directly to the girders or trusses or may be placed on top of deck bridges.

Stringers.

68. Stringers shall preferably be riveted to the webs of intermediate floor beams by means of connection angles not less than ½-inch thick. Shelf angles or other supports provided to support the stringer during erection shall not be considered as carrying any of the reaction.

Stringer Frames.

69. End floor beams shall be used if possible. Stringers resting on masonry shall be connected at their ends by cross frames. The frames shall be riveted to girders or truss shoes where practicable.

BRACING.

Rigid Bracing.

70. Lateral, longitudinal and transverse bracing shall be composed of rigid members.

Portals.

71. The end posts and top chords of the through truss spans shall be rigidly connected by riveted portal braces. The braces shall be as deep as the clearance will allow.

Transverse Bracing.

72. An intermediate transverse frame shall be used at each panel of through spans having vertical truss members where the clearance will permit.

End Bracing.

73. Deck spans shall have transverse bracing at each end proportioned to carry the lateral load to the support.

Laterals.

74. The minimum sized angle to be used in lateral bracing shall be 3½ by 3 by ⅜ inches. There shall be not less than three rivets at each end connection of the angles.

75. Lateral bracing beneath the track shall be low enough to clear the ties.

Tower Struts.

76. The struts at the base of viaduct towers shall be strong enough to slide the movable shoes when the track is unloaded.

PLATE GIRDERS.

Camber.

77. If camber is desired it shall be provided in plate girder spans over 50 feet in length at the rate of $\frac{1}{16}$-inch per 10 feet of length.

Top Flange Cover.

78. Where flange cover plates are used, one cover plate of the top flange shall extend the whole length of the girder.

Web Stiffeners.

79. There shall be web stiffeners, generally in pairs, over bearings, and at points of concentrated loading. Other web stiffeners shall be

used if the width of the unsupported web between flange angles is greater than 60 times its thickness. The distance between stiffeners shall not exceed

(a) 6 feet,
(b) the width of the unsupported web,
(c) the value of d in the following formula:

$$d = \frac{t}{40}(12{,}000 - s),$$

Where d = clear distance between stiffeners of flange angles.
t = thickness of web.
s = shear per square inch.

The stiffeners at the ends and at points of concentrated loading shall be proportioned by the formula of paragraph 16, by assuming the effective length of column equal to one-half the depth of the girder. End stiffeners and those under concentrated loading shall be on fillers. Their outstanding legs shall be as wide as the flange angles will allow and shall fit tightly against them. Intermediate stiffeners may be crimped or on fillers and their outstanding legs shall be not less than 2 inches plus one-thirtieth of the depth of the girder.

Stays for Top Flanges.

80. Top flanges of through plate girders shall be stayed by knee braces or gusset plates at every floor beam, or in solid floor bridges at distances not exceeding 12 feet.

TRUSSES.

Camber.

81. Truss spans shall be given a camber by so proportioning the length of the members that the tops of the stringers will be in a straight line when the bridge is fully loaded.

Rigid Members.

82. Hip verticals and members performing similar functions and the two end panels of the bottom chords of single track pin-connected trusses shall be rigid.

Eye-Bars.

83. The eye-bars composing a member shall be so arranged that adjacent bars will not be in contact. The bars shall be as nearly parallel to the axis of the truss as possible, the maximum inclination of any bar being one inch in 16 feet.

Pony Trusses.

84. Pony trusses shall be riveted structures with double webbed chords. The web members shall be laced or otherwise effectively stiffened.

Part Second—Materials and Workmanship.

(5) MATERIAL.

Steel.

85. Steel shall be made by the open-hearth process.

Properties.

86. The chemical and physical properties shall conform to the following limits:

Elements Considered	Structural Steel	Rivet Steel	Steel Castings
Phosphorus, max.... Basic.....	0.04 per cent.	0.04 per cent.	0.05 per cent.
Phosphorus, max.... Acid......	0.06 "	0.04 per cent.	0.08 per cent.
Sulphur, maximum...............	0.05 "	0.04 per cent.	0.05 per cent.
Yield point, minimum Pounds per square inch.........	30,000	25,000	33,000
Ultimate tensile strength. Pounds per square inch...........	Desired. 60,000	Desired. 50,000	Not less than 65,000
Elong., min. %, in 8 in. Fig. 1....	$\frac{1{,}500{,}000}{\text{Ult. tensile str'gth}}$*	$\frac{1{,}500{,}000}{\text{Ult. tensile str'gth}}$	15 per cent.
" " " 2 in. " 2.......	22		
Character of Fracture............	Silky	Silky	Silky or fine granular
Cold Bends without Fracture....	180° flat†	180° flat‡	90° $d = 3t$

* See paragraph 96. † See paragraphs 97, 98, and 99. ‡ See paragraph 100.

87. In order that the ultimate strength of full-sized annealed eyebars may meet the requirements of paragraph 163, the ultimate strength in test specimens may be determined by the manufacturers. The tests other than those for ultimate strength shall conform to the above requirements.

Allowable Variations.

88. If the ultimate strength varies more than 4000 lbs. from that desired, a retest shall be made on the same gage, which, to be acceptable, shall be within 5000 lbs. of the desired ultimate.

Chemical Analyses.

89. Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel. A copy of each analysis shall be furnished to the Engineer or his inspector. Check analyses shall be made from finished material, if called for by the purchaser, in which case an excess of 25 per cent. above the limits specified will be permitted.

Specimens.

90. Plate, shape and bar specimens for tensile and bending tests shall be made by cutting coupons from the finished product. The test specimens shall have both faces rolled and both edges milled either parallel or to the form shown by Fig. 1; or the specimens may be turned to a diameter of ¾ inch for a length of at least 9 inches, with enlarged ends.

91. Test specimens of rivet steel shall be cut full size from the rods as rolled.

92. Pin and roller specimens shall be cut from the finished rolled or forged bar, in such manner that the center of the specimen will be one inch from the surface of the bar. The specimen for tensile test shall be turned to the form shown by Fig. 2. The specimen for bending test shall be one inch by ½ inch in section.

93. The number of tests of steel castings shall depend on the character and importance of the castings. Specimens shall be cut cold from coupons molded and cast on some portion of one or more castings from each melt or from the sink heads, if the heads are of sufficient size. The coupon or sink head, so used, shall be annealed with the casting before it is cut off. Test specimens shall be of the form prescribed for pins and rollers.

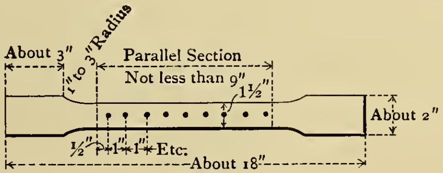

FIG. 1.

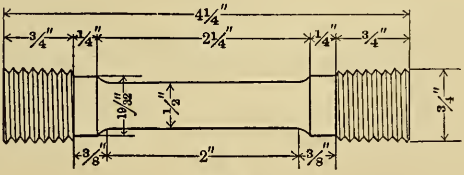

FIG. 2.

93*a*. The yield point shall be determined by the drop of beam of the testing machine. The beam shall be kept balancing between the upper and lower cross-pieces for some time preceding the drop. The speed of the machine shall be such that the beam may be kept balanced and, except for the initial tightening of the specimen in the grips, shall not exceed

½-inch per minute for the standard form of specimen for plates, bars and shapes, and shall not exceed ⅛-inch per minute for the standard form of specimen for pins, rollers and steel castings. The speed after the yield point shall not exceed 6 inches per minute, and the beam shall be kept at balance when the ultimate strength is attained.

Specimens of Rolled Steel.

94. Rolled steel shall be tested in the condition in which it comes from the rolls.

Number of Tests.

95. At least one tensile and one bending test shall be made from each melt of steel as rolled. In case steel differing ⅜-inch or more in thickness is rolled from one melt, tests shall be made from the thickest and the thinnest material rolled.

Modification in Elongation.

96. A deduction of 1 per cent. will be allowed from the specified percentage of elongation, for each ⅛-inch in thickness above ¾-inch.

Bending Tests.

97. Bending tests may be made by pressure or by blows. Plates, shapes and bars less than one inch thick shall bend as called for in paragraph 86.

Thick Material.

98. Full-sized material for eye-bars and other steel one inch thick and over, tested in the same condition as when rolled, shall bend cold 180 degrees around a pin, the diameter of which is equal to twice the thickness of the bar, without fracture on the outside of the bend.

Bending Angles.

99. Angles ¾-inch and less in thickness shall open flat, and angles ½-inch and less in thickness shall bend shut, cold, under blows of a hammer, without sign of fracture. This test shall be made only when required by the inspector.

Nicked Bends.

100. Rivet steel, when nicked and bent around a bar of the same diameter as the rivet rod, shall give a gradual break and a fine silky uniform fracture.

Finish.

101. Finished material shall be free from injurious seams, flaws, cracks, defective edges and other defects, and have a smooth, uniform

and workmanlike finish. Plates 36 inches in width and under shall have rolled edges.

Melt Numbers.

102. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it. Steel for pins and rollers shall be stamped on the end. Rivet and lacing steel and other small parts may be bundled with the above marks on an attached metal tag.

Defective Material.

103. Material which develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, may be rejected at the shop and shall be replaced by the manufacturer at his own cost.

Variation in Weight.

104. A variation in cross-section or weight of any piece of steel of more than 2½ per cent. from that specified will be sufficient cause for rejection, except that sheared plates shall be subject to the following permissible variations, which shall apply to single plates, when ordered to weight:

105. Plates weighing 12½ lbs. or more per square foot.

(a) Up to 100 inches wide, 2½ per cent. more or less than the nominal weight.

(b) One hundred inches wide and over, 5 per cent. more or less than the nominal weight.

106. Plates weighing less than 12½ lbs. per square foot.

(a) Up to 75 inches wide, 2½ per cent. more or less than the nominal weight.

(b) Seventy-five inches and up to 100 inches wide, 5 per cent. more or 3 per cent. less than the nominal weight.

(c) One hundred inches wide and over, 10 per cent. more or 3 per cent. less than the nominal weight.

107. Plates when ordered to gage will be accepted if they measure not more than 0.01 inch less than the ordered thickness.

108. An excess over the nominal weight, corresponding to the dimensions on the order, will be allowed for each plate, if not more than

that shown in the following table, one cubic inch of rolled steel being assumed to weigh 0.2833-lb.:

Thickness Ordered	Nominal Weights	Width of Plate			
		Up to 75″	75″ and up to 100″	100″ and up to 115″	Over 115″
¼-inch	10.20 lbs.	10 per cent.	14 per cent.	18 per cent.	....
5/16 "	12.75 "	8 "	12 "	16 "	....
⅜ "	15.30 "	7 "	10 "	13 "	17 per cent.
7/16 "	17.85 "	6 "	8 "	10 "	13 "
½ "	20.40 "	5 "	7 "	9 "	12 "
9/16 "	22.95 "	4½ "	6½ "	8½ "	11 "
⅝ "	25.50 "	4 "	6 "	8 "	10 "
Over ⅝ "	....	3½ "	5 "	6½ "	9 "

Cast-Iron.

109. Castings shall be made of tough gray iron, with sulphur not over 0.10 per cent., except where chilled iron is specified. They shall be true to pattern, out of wind and free from flaws and excessive shrinkage. If tests are required, they shall be made on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar 1¼ inches in dimeter and 15 inches long. The transverse test shall be made on a clear span of 12 inches with the load at the middle. The minimum breaking load so applied shall be 2,900 lbs., with a deflection of at least 1/10 inch before rupture.

Wrought-Iron.

110. Wrought-iron shall be double-rolled, tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and free from surface defects. When tested in specimens of the form of Fig. 1, or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lbs. per square inch, an elongation of at least 18 per cent. in 8 inches, with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent. fibrous.

(6) INSPECTION AND TESTING AT THE MILLS.

Mill Orders.

111. The purchaser shall be furnished complete copies of mill orders, and no material shall be rolled nor work done before the purchaser has been notified where the orders have been placed, so that he may arrange for the inspection.

Facilities for Inspection.

112. The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of all material at the mill where it is manufactured. He shall furnish a suitable testing machine for testing the specimens, as well as prepare the pieces for the machine, free of cost to the purchaser.

Access to Mills.

113. The inspector representing the purchaser at the mills shall have access, at all times, to all parts of the mills where material to be inspected by him is being manufactured.

(7) WORKMANSHIP.

General.

114. All parts forming a structure shall be built in accordance with approved drawings. The workmanship and finish shall be equal to the best practice in modern bridge works. Material at the shops shall be kept clear and protected from the weather.

Straightening.

115. Material shall be thoroughly straightened in the shop, by methods that will not injure it, before being laid off or worked in any way.

Finish.

116. Shearing and chipping shall be neatly and accurately done and all portions of the work exposed to view neatly finished.

Size of Rivets.

117. The size of rivets, called for on the plans, shall be the actual size of the rivet before heating.

Rivet Holes.

118. If general reaming is not required, the diameter of the punch shall be not more than $\frac{1}{16}$-inch greater than the diameter of the rivet; nor the diameter of the die more than $\frac{1}{8}$-inch greater than the diameter of the punch. Material more than $\frac{3}{4}$-inch thick shall be sub-punched and reamed or drilled from the solid.

Punching.

119. Punching shall be accurately done. There shall be no drifting to enlarge unmatched holes. If the holes must be enlarged to admit the rivet, they shall be reamed. Poor matching of holes will be cause for rejection.

Reaming.

120. Where sub-punching and reaming are required, the diameter of the punch used shall be not less than $\frac{3}{16}$-inch smaller than the nominal diameter of the rivet. The holes shall then be reamed to a diameter not more than $\frac{1}{16}$-inch greater than the nominal diameter of the rivet. (See 135.)

Reaming After Assembling.

121. *[If general reaming is required it shall be done after the pieces forming one built member are assembled and so firmly bolted together that the surfaces are in close contact. If it be necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted.]

122. Reaming shall be done with twist drills without lubricant.

123. The outside burrs on reamed holes shall be removed to the extent of making a $\frac{1}{16}$-inch fillet.

Assembling.

124. The parts of riveted members shall be well pinned and firmly drawn together with bolts, before riveting is commenced. Contact surfaces shall be painted. (See 152.)

Lacing Bars.

125. The ends of lacing bars shall be neatly rounded, unless otherwise called for.

Web Stiffeners.

126. Stiffeners shall fit neatly between the flanges of girders. Where tight fits are called for, the ends of the stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

Splice Plate and Fillers.

127. Web splice plates and fillers under stiffeners shall be cut to fit within $\frac{1}{8}$-inch of the flange angles.

Web Plates.

128. Web plates of girders, which have no cover plates, shall be flush with the backs of the flange angles or project above them not more than $\frac{1}{8}$-inch, unless otherwise called for. When web plates are spliced, not more than $\frac{1}{4}$-inch clearance between ends of plates will be allowed.

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* See Addendum, clause (d).

Floor Beams and Stringers.

129. The main sections of floor beams and stringers shall be milled to exact length after riveting and the connection angles accurately set flush and true to the milled ends.* [If required by the purchaser the milling shall be done after the connection angles are riveted in place, the milling to extend over the entire face of the member]. The removal of more than 3/32-inch from the thickness of connection angles will be cause for rejection.

Riveting.

130. Rivets shall be uniformly heated to a light cherry red heat in a gas or oil furnace so constructed that it can be adjusted to the proper temperature. They shall be driven by pressure tools wherever possible. Pneumatic hammers shall be used in preference to hand driving.

131. Rivet heads shall be of approved shape, uniform in size, and of neat and finished appearance. They shall be central on the shank and shall grip the assembled pieces firmly. Recupping and caulking will not be allowed. Loose, burned or otherwise defective rivets shall be cut out and replaced. In cutting out rivets, care shall be taken not to injure the adjacent metal. If necessary, they shall be drilled out.

Turned Bolts.

132. Wherever bolts are used in place of rivets which transmit shear, the holes shall be reamed parallel and the bolts shall make a driving fit with the threads entirely outside of the holes. A washer not less than ¼-inch thick shall be used under nut.

Members to be Straight.

133. The several pieces forming one built member shall be straight and fit closely together. Finished members shall be free from twists, bends and open joints.

Finish of Joints.

134. Abutting joints shall be cut or dressed true and straight and fitted close together, especially where open to view. In compression joints, depending on contact bearing, the surfaces shall be truly faced, so as to provide even bearings after they have been perfectly aligned and riveted complete.

Field Connections.

135. Holes for floor beam and stringer connections shall be sub-punched and reamed to a steel templet not less than one inch thick. †[If

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* See Addendum, clause (f).
† See Addendum, clause (e).

required, all other field connections, except those for laterals and sway bracing, shall be assembled in the shop and the unmatched holes reamed; and when so reamed the pieces shall be match-marked before being taken apart.]

Eye-Bars.

136. Eye-bars shall be straight, true to size, and free from twists, folds in the neck or head, and other defects. The heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of the heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the Engineer; but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of the head and neck shall not vary more than $\frac{1}{16}$-inch from that specified. (See 163.)

Boring Eye-Bars.

137. Before boring, each eye-bar shall be properly annealed and carefully straightened. Pin-holes shall be in the center line of the bar and in the center of the heads. Bars of the same length shall be bored so accurately that, when placed together, pins 1/32-inch smaller in diameter than the pin-holes can be passed through the holes at both ends of the bars at the same time without forcing.

Pin Holes.

138. Pin-holes shall be bored true to gages, smooth, straight, at right angles to the axis of the member and parallel to each other, unless otherwise called for. The boring shall be done after the member is riveted.

139. The distance center to center of pin-holes shall be correct within $\frac{1}{32}$-inch, and the diameter of the holes not more than 1/50-inch larger than that of the pin, for pins up to 5-inch diameter, and $\frac{1}{32}$-inch for larger pins.

Pins and Rollers.

140. Pins and rollers shall be accurately turned to gages and shall be straight, smooth and free from flaws.

Screw Threads.

141. Screw threads shall make tight fits in the nuts and shall be U. S. standard, except above the diameter of 1⅜-inch, when they shall be made with six threads per inch.

Annealing.

142. Steel which has been partially heated shall be properly annealed except where used in minor details.

Steel Castings.

143. Steel castings shall be annealed and free from large or injurious blowholes.

Welds.

144. Welds in steel will not be allowed.

Bed Plates.

145. Expansion bed plates shall be planed true and smooth. Cast wall plates shall be planed top and bottom. The finishing cut of the planing tool shall be fine and parallel with the direction of expansion.

Pilot Nuts.

146. Pilot and driving nuts shall be furnished for each size of pin, in such numbers as may be ordered.

Field Rivets.

147. Field rivets shall be furnished to the amount of 15 per cent. plus ten rivets, in excess of the nominal number required for each size.

Shipping Details.

148. Pins, nuts, bolts, rivets and other small parts shall be boxed or crated.

Weight.

149. The scale weight of every piece and box shall be marked on it in plain figures.

Finished Weight.

150. Payment for pound price contracts shall be by scale weight. Not over 2 per cent. of the total weight of the structure as computed from the plans will be allowed for excess weight.

(8) SHOP PAINTING.

Cleaning.

*151. Steel work, before leaving the shop, shall be thoroughly cleaned and given one good coating of pure linseed oil, or such paint as may be called for, well worked into all joints and open spaces.

Contact Surfaces.

152. In riveted work, the surfaces coming in contact shall each be painted before being riveted together.

Inaccessible Surfaces.

153. Pieces and parts which will not be accessible for painting after erection, including tops of stringers, eye-bar heads, ends of posts and

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* See Addendum, clause (b).

chords, etc., shall have an additional coat of paint before leaving the shop.

Condition of Surfaces.

154. Painting shall be done only when the surface of the metal is perfectly dry. It shall not be done in wet or freezing weather, unless protected under cover.

Machine-Finished Surfaces.

155. Machine-finished surfaces shall be coated with white lead and tallow before shipment and before being put out into the open air.

(9) INSPECTION AND TESTING AT THE SHOPS.

Facilities for Inspection.

156. The manufacturer shall furnish all facilities for inspecting and testing the weight of material and quality of workmanship at the shop where material is manufactured. He shall furnish a suitable testing machine for testing full-sized members, if required.

Starting Work.

157. The purchaser shall be notified well in advance of the start of the work in the shop, in order that he may have a representative on hand to inspect material and workmanship.

Access to Shop.

158. The inspector shall have access, at all times, to all parts of the shop where material to be inspected by him is being manufactured.

Accepting Material.

159. The inspector shall stamp each piece accepted with a private mark. Any piece not so marked may be rejected at any time and at any stage of the work. If the inspector, through an oversight or otherwise, has accepted material or work which is defective or contrary to the specifications, this material, no matter in what stage of completion, may be rejected by the purchaser.

Shop Plans.

160. The purchaser shall be furnished complete shop plans.

Shipping Invoices.

161. Complete copies of all shipping invoices shall be furnished to the purchaser with each shipment. Shipping invoices shall show the scale weights of individual pieces.

(10) FULL-SIZED TESTS.

Eye-Bar Tests.

162. Full-sized tests of eye-bars and similar members, to prove the workmanship, shall be made at the manufacturer's expense, and the members so tested shall be paid for by the purchaser at contract price, if the tests are satisfactory. If the tests are not satisfactory, the members represented by them will be rejected.

163. In eye-bar tests, the minimum ultimate strength shall be 55,000 lbs. per square inch. The elongation in 10 feet, including the fracture, shall be not less than 15 per cent. Bars shall generally break in the body and the fracture shall be silky or fine granular. The elastic limit as indicated by the drop of the mercury shall be recorded. Should a bar break in the head and develop the specified elongation, ultimate strength and character of fracture, it shall not be cause for rejection, provided not more than one-third of the total number of bars tested break in the head (see 136).

ADDENDUM TO GENERAL SPECIFICATIONS FOR STEEL RAILWAY BRIDGES.

Points to be Specifically Determined by Buyers When Soliciting Proposals for Steel Railway Bridges.

When general detail drawings are not furnished for the use of bidders specific answers should be given to question a, b and c, below.

Specific answers should also be given to questions d, e and f if the class of work described in any of the paragraphs there referred to is desired. If these features are not specifically demanded, the unbracketed paragraph will be construed to define the kind of work desired.

(a) What class of live load shall be used? (Paragraphs 7 and 8.)

(b) Shall linseed oil or paint be used. If paint, what kind? (Paragraph 151.)

(c) Shall the contractor furnish floor bolts?

(d) Shall general reaming be done? (Paragraph 121.)

(e) Shall field connections be assembled at the shop? (Paragraph 135.)

(f) Shall floor connection angles be milled after riveting? (Paragraph 129.)

[3]CLASSIFICATION OF BRIDGES AS TO SAFE CARRYING CAPACITY.

Carrying Capacity.

(1) The carrying capacity of a bridge is here understood to mean the heaviest moving loads which may be operated over it in regular service for a limited time without subjecting it to such severe stresses, motion or wear of parts as to seriously impair its safety and serviceability.

(2) The carrying capacity of any bridge will depend upon a large number of controlling factors, all of which must be taken into consideration. Some of these factors are design, material, workmanship, speed, stress, behavior, physical condition and the possibility of maintaining falsework for a considerable time should the bridge show distress under the increased loading.

(3) A railway bridge which has been constructed in accordance with a specification which provides for strength, design, material and workmanship at least equal to the specifications for steel railway bridges of the American Railway Engineering Association, will, when in good condition, carry for a limited period a loading in excess of that for which it was originally designed. The bridge, however, will be subjected to a greater amount of motion and wear of parts, have a lower margin of safety, less efficiency and a shorter life.

(4) When the span is less than 200 feet, all controlling factors given in paragraph 2 good, the mathematical analysis made in accordance with the American Railway Engineering Association specification, using full specification allowance for impacts for regular service, fast speed, and one-half of these impact allowances for speeds not exceeding 15 miles per hour, then, so long as the controlling factors remain good, unit stresses in tension to the extent of 26,000 lbs. in structural open-hearth steel and 22,000 lbs. in wrought-iron, will not, in themselves, be sufficient justification for suspending traffic or condemning the structure.

(5) When the controlling factors as outlined in paragraph 2 are not good, the limiting stresses or capacities cannot be determined by any general rule, as they are questions of actual conditions, judgment and experience, supplemented by a close watch on the structure in service.

Classification for Operating Purposes.

(1) Bridges should be classified for operating purposes according to their efficiencies under a loading of the type outlined in the American

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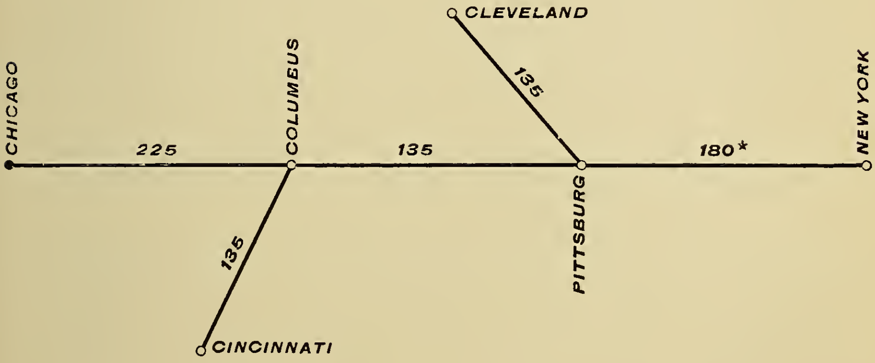
[3] Adopted, Vol. 9, 1908, pp. 218-221, 285-296.

Railway Engineering Association specifications. The efficiencies should be indicated by figures representing either the total weight or driving axle weight of the heaviest permissible engine of the specification type, and these figures should be placed on the map of the railway in such a manner as to show at a glance the capacity of the weakest structure on the main line, branches and engine districts. A schedule on this map will give the service classes of engines and cars whose operation is permitted by the stated efficiencies. Notes on the map will indicate restrictions as to speed and doubleheaders, and in order that these notes may not be overlooked an asterisk may be placed after the number indicating the efficiency on that section of the road where there are restrictions as to doubleheaders and speed. The accompanying map illustrates briefly the above scheme.



Schedule showing heaviest equipment of each service class which may be operated when the bridge efficiency is stated:

Efficiency.	*Service Class.*			
225	A250	B240	C130	D220
180	A200	B190	C180	D170
135	A150	B140	C130	D120

The figures denote weight in 1000 lbs. of engine, exclusive of tender.

Speed restriction: Ten miles on Bridge 23 at Pittsburgh.

Doubleheaders: No restriction except ....

Note.—If preferred, the efficiency may be indicated by the driving axle-load in accordance with Cooper's series instead of by the weight as above shown.

[4]INSPECTION OF BRIDGES AND RECORDS OF INSPECTION.

(1) Inspection by the regular section forces, daily, or as often as they inspect the track under their supervision. The object of this inspection is to discover any damage to the structure from fire, flood, derailments or other accidents from traffic, or any displacement in the structure in whole or in part. This inspection, due to the lack of skill on the part of the section forces, must necessarily be superficial, and will rarely, if ever, do more than call attention to unsafe conditions arising from causes other than those of natural depreciation. No reports of such inspections need be made unless adverse conditions are discovered.

(2) At periodic intervals of from one to six months there should be inspections by bridge foremen and others experienced in bridge repairs. These inspections should be more thorough than those of the section forces, and are intended to discover all the defects, arising from traffic, to which the bridge is subjected, and those due to natural depreciation or other causes. Reports of such inspections should be made to the one next in authority; preferably to the one most directly or primarily responsible for the safety of the structures.

(3) Annual or semi-annual inspections are to be made by men experienced in the design and maintenance of bridges; preferably by those who are primarily responsible for their safe maintenance. The reports of these inspections should be filed, and in connection with an examination of office data will determine the safety of the structures, and be the basis for decisions as to repairs, reinforcements or renewals.

[5]SPECIFICATIONS FOR THE ERECTION OF RAILROAD BRIDGES.

Work to Be Done.

1. The contractor shall erect, rivet and adjust all metal work in place complete, and perform all other work hereinafter specified.

Plant.

2. The contractor shall provide all tools, machinery and appliances necessary for the expeditious handling of the work, including drift pins and fitting up bolts.

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[4] Adopted, Vol. 11, Part 1, 1910, pp. 126, 127, 166.

[5] Adopted, Vol. 13, 1912, pp. 83-87, 935-945.

Falsework.

3. The method of erection and plans for falsework and erection equipment shall be subject to approval by the Engineer, but such approval shall not relieve the contractor from any responsibility. Falsework will be built by *.............................. Falsework material of every character will be provided by the *................................

The temporary structure for use during erection and for maintaining the traffic shall be properly designed and substantially coustructed for the loads which will come upon it. All bents shall be thoroughy secured against movement, both transversely and longitudinally. The bents shall be well secured against settling, and piles used wherever firm bottom cannot be obtained. Upon completion of the erection, the temporary structure, if the property of the Railway Company, shall be removed without unnecessary damage, and neatly piled near the site or loaded on cars, as may be directed. If the property of the contractor, it shall be removed in a manner subject to the approval of the Engineer.

Falsework placed by the Railway Company under an old structure or for carrying traffic, may be used as far as practicable by the contractor during erection, but it shall not be unnecessarily cut or wasted.

Conduct of Work.

4. The work shall be prosecuted with sufficient force, plant and equipment to expedite its completion to the utmost extent and in such a manner as to be at all times subordinate to the use of the tracks by the Railway Company, and so as not to interfere with the work of other contractors, or to close or obstruct any thoroughfare by land or water, except under proper authority.

Reasonable reduction of speed will be allowed upon request of the contractor.

Tracks shall not be cut nor shall trains be subjected to any stoppage except when specifically authorized by the Engineer.

The contractor shall protect traffic and his work by flagman furnished by and at the expense of the Railway Company. The contractor shall provide competent watchmen to guard the work and material against injury.

Engine Service.

5. If under the contract, work train or engine service is furnished the contractor free of charge, such service shall consist only in unloading materials and in transferring the same from a convenient siding to the

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* Insert "Railway Company" or "Contractor," as the case may be.

bridge site. Other engine service shall be paid for by the contractor at the rate of $.............. per day per engine, the time to include the time necessary for the engine to come from and return to its terminal. When engine service is desired the contractor shall give the proper railway officials at least 24 hours' advance notice and the Railway Company will furnish the service as promptly as possible, consistent with railroad operations.

When derrick cars are used on main tracks, their movements shall be in charge of a train crew, and the expense of the crew and any engine service other than as noted above shall be charged to the contractor.

Transportation.

6. When transportation of equipment, materials and men is furnished free over the Railway Company's line, it shall be subject to such conditions as may be stated in the contract.

Masonry.

7. The Railway Company will furnish all masonry to correct lines and elevations, and unless otherwise stated in the contract, will make all changes in old masonry without unnecessarily impeding the operations of the contractor. The Railway Company's Engineer will establish lines and elevations and assume responsibility therefor, but the contractor shall compare the elevations, distances, etc., shown on plans, with the masonry as actually constructed as far as practicable, before he assembles the steel. In case of discrepancy, he shall immediately notify the Engineer.

Handling and Storing of Materials.

8. Cars containing materials or plant shall be promptly unloaded upon delivery therefor, and in case of failure to do so the contractor shall be liable for demurrage charges. Material shall be placed on skids above the ground, laid so as not to hold water, and stored and handled in such a manner as not to be injured or to interfere with railroad operations. The expense of repairing or replacing material damaged by rough handling shall be charged to the contractor. The contractor, while unloading and storing material, shall compare each piece with the shipping list and promptly report any shortage or injury discovered.

Maintenance of Traffic.

9. When traffic is to be maintained it will be carried on in such a manner as to interfere as little as practicable with the work of the contractor.

Changes in the supporting structure or tracks required during erection shall be at all times under the direct control and supervision of the Railway Company.

Removal of Old Structure.

10. Unless otherwise specified, metal work in the old structure shall be dismantled without unnecessary damage and loaded on cars or neatly piled at a site immediately adjacent to the tracks, and at a convenient grade for future handling, as may be directed. When the structure is to be used elsewhere all parts will be match-marked by the Railway Company; when the old bridge is composed of several spans the parts of each shall be kept separate.

Metal Work.

11. Material shall be handled without damage. Threads of all pins shall be protected by pilot and driving nuts while being driven in place.

Light drifting will be permitted in order to draw the parts together, but drifting for the purpose of matching unfair holes will not be permitted. Unfair holes shall be reamed or drilled.

Nuts on pins and on bolts remaining in the structure shall be effectively locked by checking the threads.

All splices and field connections shall be securely bolted prior to riveting. When the parts are required to carry traffic, important connections, such as attachments of stringers and floor beams, shall have at least 50 per cent. of the holes filled with bolts and 25 per cent. with drift pins. All tension splices shall be riveted up complete before blocking is removed. When not carrying traffic, at least 33⅓ per cent. of the holes shall have bolts.

Rivets in splices of compression members shall not be driven until the members shall have been subjected to full dead load stresses. Rivets shall be driven tight. No recupping or caulking will be permitted. The heads shall be full and uniform in size and free from fins, concentric and in full contact with the metal. Heads shall be painted immediately after acceptance.

Rivets shall be uniformly and thoroughly heated and no burnt rivets shall be driven. All defective rivets shall be promptly cut out and redriven. In removing rivets the surrounding metal shall not be injured; if necessary, the rivets shall be drilled out.

Misfits.

12. Correction of minor misfits and a reasonable amount of reaming shall be considered as a legitimate part of the erection.

Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins, and a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the Engineer and the work of correction done in the presence of the Engineer, who shall check the time expended.

The contractor shall render an itemized bill for such work of correction for the approval of the Engineer.

Anchor Bolts.

13. Holes for all anchor bolts, except where bolts are built up with the masonry, shall be drilled by the contractor after the metal is in place and the bolts shall be set in Portand cement grout.

Bed Plates.

14. Bed plates resting on masonry shall be set level and have a full even bearing over their entire surface; this shall be attained by either the use of Portland cement grout or mortar, or by tightly ramming in rust cement under the bed plates after blocking them accurately in position.

Decks.

15. The *.......................... will frame and place the permanent timber deck.

Painting.

16. The paint will be furnished by *.......................... and shall be of such color, quality and manufacture as may be specified.

Surfaces inaccessible after erection, such as bottoms of base plates, tops of stringers, etc., shall receive two coats of paint before assembling in place. After erection, the entire structure shall receive two coats of paint, allowing enough time between coats for the first coat to dry before applying the second. No paint shall be applied in wet or freezing weather, nor when the surface of the metal is damp. Painting shall be done in good and workmanlike manner, subject to strict inspection during progress and after completion, and in accordance with special instructions which shall be given by the Engineer. All metal shall be thoroughly cleaned of dirt, rust, loose scale, etc., before the paint is applied.

Clearing the Site.

17. The contractor, after completion of the work of erection, shall remove all old material and débris resulting from his operations and place the premises in a neat condition.

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* Insert "Railway Company" or "Contractor," as the case may be.

Superintendence and Workmen.

18. During the entire progess of the work the contractor shall have a competent superintendent in personal charge and shall employ only skilled and competent workmen. Instructions given by the Engineer to the superintendent shall be carried out the same as if given to the contractor. If any of the contractor's employés by unseemly or boisterous conduct, or by incompetency or dishonesty, show unfitness for employment on the work, they shall, upon instructions from the Engineer, be discharged from the work, nor thereafter be employed upon it without the Engineer's consent.

Inspection.

19. The work of erection shall at all times be subject to the inspection and acceptance of the Engineer.

Engineer.

20. The term "Engineer," as used herein, shall be understood to mean the Chief Engineer of the Railway Company, or his accredited representative.

[6]INSTRUCTIONS FOR THE MILL INSPECTION OF STRUCTURAL STEEL.

(1) Study the contract and specifications and secure such information concerning the proposed structure as will permit a full understanding of the use to be made of the various items of the order.

(2) Secure copies of the mill orders, shipping directions and other information concerning the material to be inspected.

(3) Attend promptly when notified of the rolling of material and so conduct the inspection and tests as not to interfere unnecessarily with the operations of the mill.

(4) Have the test specimens prepared and properly stamped with the melt numbers by the manufacturer. Observe the selection and stamping of specimens and verify the melt numbers when practicable.

(5) Attend and supervise the making of tensile, bending and drifting tests. Make sure that the testing machines are properly handled and that the specified speed of pulling is not exceeded. Note the behavior of the metal and check and record the results of the tests.

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[6] Adopted, Vol. 14, 1913, pp. 86, 87, 1049-1050.

(6) Select the bars or other members for full-size tests as specified. Supervise such tests and check and record their results.

(7) Secure from the manufacturer records of the chemical analyses of the melts and accept only those in which the specified contents of impurities are not exceeded.

(8) Secure pieces of the test ingots and test specimens and have check analyses made outside of the manufacturers' laboratory when the analyses furnished by the manufacturer are erratic or for any other reason appear to be incorrect.

(9) Examine each piece of finished material for surface defects before shipment, requiring the material to be handled in a manner that will permit the examination to be thorough and complete. This inspection should detect evidence of excessive gagging or other injury due to cold straightening.

(10) Report promptly the shipment of any material from the mill, whose surface inspection has been waived. Such material should be examined by the shop inspector.

(11) Verify the section of all material by measurements and by weight.

(12) Study the operations of the plant and become familiar with the various processes of manufacture.

Cultivate the acquaintance of the mill employés and become familiar with their work so as to have direct knowledge of the mill practice and determine as well as the circumstances permit the correctness of the mill practice in so far as it is covered by the specifications.

(13) Record all tests and analyses on the forms provided.

(14) Keep informed as to the progress of the work in the shop and endeavor to secure the shipment of material at such times and in such order as to avoid delay in the fabrication.

(15) Secure copies of the shipping lists and compare them with the orders and make regular statements of the material that has been rolled and shipped.

(16) Make reports weekly or as may be directed, submitting complete records of tests, analyses and shipments and such other information as may be required.

[7] INSTRUCTIONS FOR THE INSPECTION OF THE FABRICATION OF STEEL BRIDGES.

(1) Acquire a full knowledge of the conditions of the contract, such as the time of delivery, the railway company's actual need of the work, the desired order of shipment, and any special features in connection with the delivery, such as the position of the girders or truss members on cars at the bridge site.

(2) Study in advance the plans and specifications and see that all provisions thereof are complied with. These instructions are not to be construed as altering the specifications in any way.

(3) Endeavor to maintain pleasant relations with foremen and workmen; and by fairness, decisiveness and good sense, interest them in the successful completion of the work.

(4) Attend constantly to the work, making inspection during the progress of the work in the shop, striving to keep up with the output in order that errors may be corrected before the work leaves the shop.

Conduct the inspection so as not to interfere unnecessarily with the routine operations of the shop.

(5) When unusual circumstances require an explanation of the plans or some variation from the specified procedure, take the necessary action promptly.

(6) Study the field connections, paying particular attention to clearances and making notations on the drawings so that they may be checked rapidly.

(7) Check all bevels and field rivet holes.

(8) Give careful attention to the quality of the workmanship, the condition of the plain material, accuracy of punching, care in assembling, alinement of rivets, tightness of rivets, accuracy of finishing of machined joints, painting and general finish.

(9) Make sure that reamed holes are truly cylindrical and that drillings are not allowed to remain between assembled parts.

(10) Watch for bends, kinks and twists in the finished members and make certain that when leaving the shop members are in proper condition for erection.

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[7] Adopted, Vol. 14, 1913, pp. 87-89, 1050-1053; Vol. 15, 1914, pp. 410, 411, 1058.

(11) Make sure that the webs of girders do not project beyond the flange angles and that the depth of web below the flange angles complies with the specification.

(12) Allow only the material rolled and accepted for the work to be used therein.

(13) Have the fabricated material shipped in the correct order for erection and in accordance with instructions, as far as practicable.

(14) Measure the width of each column and the lengths of all girders between columns when they are to be placed consecutively in a long row so as to insure that the columns and girders will not "build out" in erection so as to exceed the calculated length.

(15) Check "rights" and "lefts" and make sure that the proper number of each is shipped.

(16) Check base plates of girders before riveting and make sure that the bevel is not reversed.

(17) Check the space provided for driving field rivets, allowing sufficient space for the pneumatic riveter.

(18) Examine field connections after riveting to insure proper fitting and ease of erection.

(19) Make sure that shop splices are properly fitted and that matched and milled surfaces to transmit bearing are in close contact during riveting as specified.

(20) Examine and measure bored pinholes carefully to insure proper position, dimension, spacing and smoothness of finish.

(21) Measure the spacing center to center of the end connections for sections of I-beam floors or any similar construction in which the calculated spacing is liable to be exceeded because of the tendency of such work to "grow" as it is assembled.

(22) Make sure that stringers connecting to floor beams beneath the flange have sufficient clearance to care for their possible over-run in depth.

(23) Have the assembling of trusses and girder spans required by the specifications carefully done and in any case insure the accuracy of field connections. If a large number of duplicate parts are to be made, the number of parts to be assembled should be governed by the workmanship. If errors are found, a sufficient number of parts should be assembled to make it reasonably certain that such errors have been eliminated.

(24) Secure match-marking diagrams for work which has been assembled and reamed and make sure that the match marks are plainly visible.

(25) Have proper camber blocking used in assembling trusses and secure the desired camber before the reaming is done.

(26) Require that all treads and supports for the drums of draw spans be carefully leveled with an instrument.

(27) Study carefully the machine details and discriminate between those dimensions which must be exact and those in which slight variations are permissible.

Determine in advance the desired accuracy of fits for bolts or keys and similar parts and make sure that such accuracy is attained.

(28) Examine castings carefully for blowholes and other imperfections and discriminate between such defects as are unimportant and those which render the castings unfit for use.

(29) Make sure that bushings, collars and similar parts are held securely in place.

(30) Make sure that all drum wheels, expansion rollers, turntable rollers and similar parts are exact in size, so as to carry equally the loads which may be placed upon them.

(31) Ascertain in advance that the paint provided complies with specifications. Watch carefully the painting directions and make sure that paint is properly applied and only where intended.

(32) Verify all shop marks and make sure that they are legible as well as correct.

(33) Have important members so loaded as to be headed in the right direction upon arrival at the site of the work.

(34) Try a few countersunk head bolts in the holes where they are to be used to insure a proper fit.

(35) Make sure that small pieces are bolted in place for shipment as shown on the plans and that other small parts are properly boxed or otherwise secured against loss.

(36) Make sure that rivets, tie rods, anchor bolts and miscellaneous parts are shipped so as to avoid delay in erection.

(37) Examine the field rivets to insure that they are free from fins or other defects.

(38) Exercise special care in the examination of all movable structures and particularly their moving parts.

(39) Make reports weekly or as directed, exhibiting carefully and concisely the actual conditions.

(40) Observe carefully and report such unusual difficulties as may be encountered and the means adopted in overcoming them and endeavor

by a study of the details or other means to make recommendations which will prevent their recurrence in future work.

(41) Check every finished member against the drawings for its general dimensions and for the section of each piece of material forming a component part of the member.

(42) Attend the weighing of material whenever practicable, especially that purchased on weight basis. Check the accuracy of the scales with test weights or by other sufficient means.

[8]INSTRUCTIONS FOR THE INSPECTION OF BRIDGE ERECTION.

(1) Study and observe the plans and specifications for steel construction. Study the masonry plans and check the masonry as built with the steel plans.

(2) Familiarize yourself with the local conditions affecting erection. Make the acquaintance of the principal men engaged upon the work and of local residents whose interests may be affected thereby.

(3) Obtain and study carefully the employés timetable and be well posted concerning the time and relative importance of regular and extra trains. Acquaint yourself with all special traffic arrangements made because of the work in hand.

(4) Secure full information concerning the conditions of the work in the bridge shop and the probable dates of shipment.

(5) Obtain reports of any uncompleted or erroneous work that must be attended to after arrival of the material in the field.

(6) Study the erection program in order to avoid delays and be able to recommend some other procedure in an emergency.

(7) Endeavor to have full preparations made before disturbing the track so that the erection may proceed rapidly and the period of such disturbance be made a minimum.

(8) Keep a record of the arrival of all materials. The contractor's record should be sufficient if available. Strive to anticipate any shortage of material and use all available facilities to hasten delivery of the needed parts.

(9) Study the progress of the work and determine whether it is likely to be completed in the time allotted. If not, endeavor to secure such additions to the force and equipment as will insure such completion.

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[8] Adopted, Vol. 14, 1913, pp. 90, 91, 1053-1057.

(10) Make a daily record of the force employed and the distribution of labor, in a way that will assist in following paragraphs 9 and 23.

(11) Exercise a constant supervision of any temporary structure or falsework and make soundings if necessary with the purpose of discovering any evidence of failure or lack of safety and having it corrected before damage is done. Examine erection equipment with a view to its safety and adequacy.

(12) Be constantly on hand when work is in progress and note any damage to the metal, failure to conform to the specifications, or any especial difficulty in assembling.

(13) Make sure that each member of the structure is placed in its proper position. If match marks are used, examine them with care.

Endeavor to have the several members assembled in such order that no unsatisfactory makeshifts need be resorted to in getting some minor member in place.

(14) Prevent any abuse or rough usage of the material. Bending, straining and heavy pounding with sledges are included in such abuse.

(15) Watch carefully the use of fillers, washers and threaded members to see that they are neither omitted nor misused.

(16) Make certain that all parts of the structure are properly aligned and that the required camber exists before riveting. It is possible for a structure to be badly distorted, although the rivet holes are well filled with bolts.

(17) Watch the heating of rivets to prevent underheating or overheating and to make sure that scale is removed.

Examine and test carefully all field-driven rivets and have any that are loose or imperfect replaced.

Have cut out and replaced all rivets, whether shop-driven or field-driven, that may be loosened during erection and riveting.

Prevent injury to metal while removing rivets.

(18) Present to the contractor at once for his attention any violation of the specifications or contract, and secure a correction or refer the matter to the proper authorities as soon as possible.

(19) Keep informed concerning the use of Company material and work trains and assist in procuring such material and trains when needed, and preserve a record thereof.

(20) Secure a match-marking diagram of any old structure to be removed which it is desired to re-erect and see that each part of such structure is properly marked in accordance therewith. Make a record of

the manner of cutting the old structure apart and report any damage to the members of the old structure. Indicate by sketches or otherwise such repairs or replacements as will be found necessary in re-erection.

(21) Secure photographic records of progress and the important features of the work wherever practicable.

(22) Make a record of all flagging of trains, whether performed for the benefit of the contractor or otherwise, delay to trains, personal injuries and accidents of every kind.

(23) Make reports as directed, showing the progress of the work, the size of the force and the equipment in use.

Make a final report showing the cost of labor of erection per ton of material erected, the cost of labor per rivet in riveting, the cost of correcting errors in design and fabrication and commenting on the design and details; and give such other information as may be useful in planning similar work.

COMMITTEE XVI.

ECONOMICS OF RAILWAY LOCATION.

[1] ECONOMICS OF RAILWAY LOCATION.

(1) A line is located when its position is fixed horizontally and vertically.

(2) Locating a railway means designing an economical plant for handling a given traffic. The economical plant for a given quantity and class of traffic may not be the economical plant for a greater or less quantity of traffic or for traffic of a different class. It is considered good practice to discount the future within reasonable limits, provided the necessary funds are available.

(3) The most general formula for the economic value of a location is:

$$\frac{R-E}{C}=p \qquad (1)$$

Where $R=$ Annual revenue (receipts from operation);

$E=$ Annual expense of operation, including depreciation and taxes;

$C=$ Capital invested (cost of construction);

$p=$ Percentage of profit on investment.

(4) The following equation may be used in certain cases, especially where the annual revenue, known or unknown, is constant:

$$R-(E+I)=P \qquad (2)$$

Where $I=$ Amount of interest on cost of construction;

$P=$ Amount of profit (net corporate income).

When the revenue is constant the condition of equation (2) is that the sum of operating expenses, plus interest on cost of construction, shall be a minimum, and is convenient in many cases, but does not indicate the proportion of profit to investment. Care should be taken not to use too low a rate of interest. The ratio of profit to investment should be considered.

(5) In order to make an economical location of a railway, the Engineer must know or make a reasonable assumption of the amount, direction and class of traffic that the railway will be called upon to

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[1] Adopted, Vol. 16, 1915, pp. 104, 1078.

handle, class of power and the approximate efficiency and cost of fuel that will be used, the rate of wages that will be paid to employés, the cost of maintenance materials, and the rate of interest considered a proper return for additional expenditures involved in the improvement of the line for the reduction of operating expenses.

(6) The engine district should be sufficiently long to obviate constructive mileage and short enough to enable the maximum slow freight train to make the run within the hours of service required.

One of the necessary requisites for a terminal point is a suitable water supply for locomotives and for domestic use. It is desirable, where possible, that terminal points should be located on minor summits.

(7) Passing sidings and road water supplies should preferably be located on minor summits.

(8) If passing sidings must of necessity be located on ruling gradients, then such gradients should be compensated through and preferably for a full train length in each direction from either end of the siding. The rate of compensation will be governed by the ruling gradient.

(9) In deciding upon the ruling gradient for each engine district, where different ruling gradients are contemplated for adjoining districts carrying approximately equal traffic, due consideration must be given to the breaking up of trains, which may be caused by the difference in ruling gradients. Where a fixed elevation is to be overcome, the development of distance to reduce the rate of ruling gradient is often a mistake, provided the ruling gradient of the shorter line is within reasonable operating limits. Where curvature and distance are introduced for the sake of ruling gradient reduction; line resistance, time, and thereby fuel consumption, is increased, as is also the cost of maintenance of way and equipment. Some of the benefits derived from a reduction of ruling gradient are the saving in weight of locomotives to be lifted over the summit, train and engine wages and engine mileage reduced and the capacity of the track increased. Full advantage cannot be taken of the apparent train rating increase due to ruling gradient reduction on an engine district having a large percentage of grade at or near the proposed ruling rate, as in all probability, if this anticipated increase in rating is in direct proportion to the proposed reduction in ruling gradient, the required time for movement of trains over the engine district cannot be made. On crowded single-track lines a feature affecting train rating to a great extent is the loss of time at meeting and passing points; it, therefore, is necessary to estimate the train rating for any line as the

tonnage that can be handled in a given time, due allowance being made for necessary stops.

In estimating the time required for trains to pass over an engine district, a speed curve and time card should be plotted.

There is little increase of tonnage for local and fast freights, and none for passenger trains, to be credited to a reduction of ruling gradient on lines with light undulating grades.

In establishing a ruling gradient and determining the effect of it on future operating expense, due consideration must be given to possible future revisions of the line; thus, in comparing alternative locations, one of steep ruling gradient may appear more economical than another of low ruling gradient, but the situation of the former may be such that its revision would necessitate an abandonment of all or a large percentage of the location; while the application temporarily of a steep ruling gradient to the low-gradient location might bring the cost of the latter line within such limits that, considering future traffic, its construction would be desirable.

(10) In the construction of a line where the contemplated immediate traffic is small and the future traffic large, sharp curvature and steep temporary gradients, so situated as to be possible of reduction when justified by the traffic, may be advantageously introduced; a line being thus constructed which will provide for immediate requirements and which can be improved for future requirements at a reasonable expense. Before deciding upon such temporary expedients, care should be taken to compare the cost of the work ultimately to be abandoned with the interest saved on the extra cost of construction that would have been necessary to construct a line on the final location during that period in which the more expensive construction would appear uneconomical.

In the construction of temporary lines due consideration must be given to the location of stations, and these should not be located on portions of the line where revisions are contemplated, owing to the fact that if a receiving and delivery point for local traffic is once established, opposition from the public may prevent its removal.

In the matter of terminal property the future requirements should be estimated for a longer period than is justified for the line between terminals.

(11) Momentum gradients, not exceeding that over which a locomotive loaded for the ruling gradient can handle its train in two parts if stalled for any reason in the sag, may be used to reduce construction cost without decreasing the train rating or the efficiency of the railway,

and should be used where economy in construction cost is thereby effected, except at points where train stops or reduced speed, below the limit necessary to operate the gradient, are likely to be necessary.

In the calculation of the lengths of momentum gradients the maximum speed of freight trains at the bottom of the sag should not exceed the speed limit for such trains on the engine district under consideration; and the minimum speed at the top of the grade, where the velocity grade adjoins an ascending grade of any considerable length, should not be less than eleven miles per hour. Where the top of the momentum gradient is at a summit, the minimum speed may be less than 11 miles per hour.

In fixing the grade line for any alinement, care should be taken to insert vertical curves at all grade-line intersections. Curves should be connected to tangents by spiral or easement curves of such length as to provide ample space in which to make the required superelevation, giving due consideration to future requirements of increased speeds.

(12) The location of terminal points, ruling gradient, and pusher gradients having been decided upon, the effect of the minor details of location, namely, distance, curvature, and rise and fall, upon operating expenses may be determined approximately in the following manner: Alternative locations may be compared by distance, curvature and line resistance; distance being the length of the line measured along the center line of the location; curvature the number of degrees of central angle subtended by the center line of track, and which may be divided into sharp curvature, necessitating a reduction of speed for trains, and ordinary curvature, which will again be subdivided into that increasing line resistance in both directions and that increasing line resistance in one direction only and line resistance which is the sum of the rolling resistance (or friction resistance), plus the resistance of gravity overcoming difference in elevation on up-grades, plus the resistance due to curvature, minus the energy of gravity on trains on descending grades, from which has been subtracted the loss of energy (or velocity head) due to the application of brakes. In comparing different locations the resistance under average conditions should be used.

The above method must be understood to not to take into account the resistance due to accelerating trains. This may or may not be a considerable part of the total resistance, depending on the rate of grades and the distance between stops.

Friction resistance, normal conditions, warm weather, modern freight equipment, speed between 7 and 35 miles an hour, may be obtained from the formula

$R = 2.2\ T + 121.6\ C.$

$R =$ Total resistance on level tangent.

$T =$ Total weight of cars and contents in tons.

$C =$ Total number of cars in train.

This amounts to 4 to 8 lbs. per ton, depending on whether cars are fully loaded or empty. This is equivalent to a rise of from 10 to 20 feet per mile. For mixed traffic a conservative estimate is, train resistance equals rise of 15 feet per mile. Train resistance increases at lower temperatures, and at extreme low temperature may go as high as 30 lbs. per ton for empty freight cars. However, in comparing different locations in the same country, it is deemed necessary to make comparisons for the ordinary conditions only. The resistance due to curvature may be taken at 0.04 feet per degree of central angle.

(13) To determine the relative value of the minor details of location under consideration (curvature, distance, rise and fall), it is first necessary to decide upon a method of studying the effect of these factors on the cost of operation. The following method is recommended: Curvature increases resistance at the rate of 0.04 feet per degree of central angle; it also affects the cost of maintenance of way and the cost of maintenance of equipment, but sufficient data is not available to warrant a conclusion as to the definite amounts.

Rise affects line resistance and time; the principal effects of eliminating rise will be found in the fuel account. It also affects the cost of maintenance of equipment and maintenance of track, but to what extent is unknown. It may be neglected in comparing alternate locations.

Distance affects train wages, line resistance, maintenance of way and maintenance of equipment. The effect of distance on line resistance will be found in the fuel account. The effect of distance on train wages can be computed on a direct train-mile basis. The effect of distance on maintenance of way is a more complicated problem on account of the uncertainty as to the basis on which maintenance should be calculated. A fixed sum per mile to cover factors of maintenance that are more or less constant plus a rate for the equivalent ton-mile unit, using multiples for weights of engines and passenger cars, is correct in principle, but until such time as information is obtained as to the value of these multiples, this item may be calculated on a basis of a constant per mile plus a fixed sum per train mile. The effect of distance on maintenance of equipment, for comparative purposes, may be calculated on a train-mile basis.

(14) *Special Structures.*—The maintenance and operation of special structures must be considered on their respective merits for each location.

(15) Time will not as a general thing constitute an important factor in the consideration of the minor details of location, but if the difference in time required to operate over alternative locations is of sufficient importance to affect the amount of equipment to operate the line, and consequently the annual charge for same, or the earnings of the line, or the trainmen's wages through overtime, then this item must be taken into consideration.

(16) In comparing lines of varying lengths, consideration must be given to the effect of distance upon revenue. Another item worthy of consideration is the fact that the reduction of distance in engine runs of less than 100 miles, which constitute the entire day's work for trainmen employed on same, may not reduce the amount of wages to be paid to such employés.

[2]POWER.

(1) Actual drawbar pull of the locomotive at various speeds should be used in making estimates with reference to economic value of various locations of line and grade, where such drawbar pull is known. Where not known, the drawbar pull should be calculated. In comparing a new line with an existing line the same percentage of efficiency of drawbar pull should be used in both cases.

(2) The tractive power of a locomotive depends upon its steam-producing capacity, the boiler pressure, the adhesion, and the size of the cylinders and drivers.

(3) The steam-producing capacity of a locomotive depends mainly upon the quantity and quality of the fuel burned, and the area of heating surface.

(4) Knowing the area of heating surface, the average steam production of locomotives burning bituminous and similar coals can be estimated by the use of Table 1, assuming the maximum quantity of coal that can be properly fired and consumed per hour, to be as follows:

Hand-fired locomotives	4,000 lbs. per hour
Stoker-fired locomotives with grates less than 70 square feet	6,000 lbs. per hour

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[2] Adopted, Vol. 11, Part 1, 1911, pp. 631-664, 709-715; Vol. 16, 1915, pp. 138.

Stoker-fired locomotives with grates of 70 square feet or over.......
....8,000 lbs. per hour

These amounts are to be understood as the average hourly fuel consumption, which may reasonably be expected to be maintained throughout the periods when the locomotive is working steam.

(5) The maximum velocity at which full cutoff can be maintained can be found by dividing the pounds steam produced per minute by the quantity of steam used per revolution of the drivers, as shown in Table 2. Dividing this quotient by the coefficient given in Table 3 for the diameter of the drivers will give the speed in miles per hour at which full cutoff can be maintained. This velocity is referred to as "M" in the tables.

(6) Tractive power of a locomotive is greatest at starting, gradually reducing to the maximum velocity ("M") at which full cutoff can be maintained. At speeds above this velocity the tractive power decreases more rapidly. The tractive power at any multiple of "M" is practically a fixed percentage of the tractive power at "M." The fixed percentages are different for compound types than for simple locomotives.

(7) Knowing the steam production of a locomotive and the maximum velocity at which full cutoff can be maintained ("M"), the indicated horsepower of the locomotive can be obtained for velocity "M" or higher velocities by dividing the total steam produced per hour by the quantity of steam used per I.H.P. hour, as given in Table 4, after applying the corrections for proper boiler pressure in the case of a locomotive using saturated steam.

(8) Horsepower can be converted into tractive power by the formula, tractive power equals 375 times the H.P., divided by the velocity in miles per hour. To simplify the operation, the tractive power can be obtained by multiplying the H.P. by the figures shown in Table 6.

(9) Where I. H. P. at "M" velocity has been converted into cylinder tractive power, the cylinder tractive power at other multiples of "M" can be determined by using the percentages given in Table 5 without first calculating the I.H.P. for the respective multiples of "M."

(10) Available drawbar pull on level tangent is the cylinder tractive power less the sum of the resistance from the cylinder to the rim of drivers, the resistance through the trucks of engine and tender; and the "head end" or velocity resistance. The formulas and data given in Table 7 are recommended for use in determining these resistances. Available drawbar pull at starting, with use of sand, should not be considered as

greater than 30 per cent. of the weight on locomotive drivers and at running speeds not greater than 25 per cent.

TABLE 1

AVERAGE EVAPORATION IN LOCOMOTIVE BOILERS

Burning bituminous and similar coals of various qualities and for various quantities consumed per square foot of heating surface per hour.

Based on Feed Water at 60° Fahrenheit. Boiler Pressure, 200 lbs.

Lbs. Coal per Sq. Ft. H. Surface per Hour	Pounds Steam per Pound of Coal of Given Thermal Value					
	10,000 B. T. U.	11,000 B. T. U.	12,000 B. T. U.	13,000 B. T. U.	14,000 B. T. U.	15,000 B. T. U.
0.8	5.24	5.76	6.29	6.81	7.34	7.86
0.9	5.05	5.56	6.06	6.57	7.07	7.58
1.0	4.87	5.36	5.85	6.34	6.82	7.31
1.1	4.71	5.18	5.65	6.12	6.59	7.06
1.2	4.55	5.00	5.46	5.91	6.37	6.82
1.3	4.39	4.83	5.27	5.71	6.15	6.59
1.4	4.25	4.67	5.10	5.52	5.95	6.37
1.5	4.11	4.52	4.94	5.35	5.76	6.17
1.6	3.98	4.38	4.78	5.18	5.57	5.97
1.7	3.86	4.25	4.63	5.02	5.40	5.79
1.8	3.74	4.12	4.49	4.86	5.24	5.61
1.9	3.63	3.99	4.35	4.71	5.08	5.44
2.0	3.51	3.86	4.22	4.57	4.92	5.27
2.1	3.41	3.75	4.10	4.44	4.78	5.12
2.2	3.31	3.64	3.98	4.31	4.64	4.97
2.3	3.22	3.54	3.86	4.19	4.51	4.83
2.4	3.13	3.44	3.75	4.07	4.38	4.69
2.5	3.04	3.34	3.65	3.95	4.26	4.56
2.6	2.96	3.25	3.55	3.84	4.14	4.44
2.7	2.88	3.17	3.46	3.74	4.03	4.32
2.8	2.80	3.09	3.37	3.64	3.93	4.21
2.9	2.73	3.01	3.28	3.55	3.83	4.10
3.0	2.66	2.93	3.19	3.46	3.73	3.99

The quantity of steam evaporated for intermediate quantities or qualities of coal can be found by interpolation.

On bad water districts deduct the following from tabular quantities:

For each $\frac{1}{16}$-inch of accumulated scale ....10 per cent.

For each grain per U. S. gallon of foaming salts in the average feed water.............................. 1 per cent.

For locomotive using superheated steam, the heating surface mentioned in column 1 is to be understood as total water-heating surface only—superheating surface is not included.

TABLE 2

Weight of Steam Used in One Foot of Stroke in Locomotive Cylinders.

(a) For locomotives using saturated steam.

Cylinder diameter is for high pressure cylinders in compound locomotives.

Diameter of Cylinder in Inches	Weight of Steam per Foot Stroke for Various Gage Pressures						
	160 lbs.	170 lbs.	180 lbs.	190 lbs.	200 lbs.	210 lbs.	220 lbs.
12	0.304 lbs.	0.321 lbs.	0.337 lbs.	0.354 lbs.	0.370 lbs.	0.389 lbs.	0.405 lbs.
13	0.357 “	0.376 “	0.396 “	0.415 “	0.435 “	0.456 “	0.475 “
14	0.414 “	0.436 “	0.459 “	0.482 “	0.504 “	0.529 “	0.551 “
15	0.476 “	0.501 “	0.527 “	0.553 “	0.579 “	0.607 “	0.633 “
15½	0.508 “	0.535 “	0.562 “	0.590 “	0.618 “	0.649 “	0.675 “
16	0.541 “	0.570 “	0.599 “	0.629 “	0.658 “	0.691 “	0.720 “
17	0.611 “	0.643 “	0.676 “	0.710 “	0.744 “	0.780 “	0.812 “
18	0.685 “	0.722 “	0.759 “	0.796 “	0.834 “	0.875 “	0.911 “
18½	0.724 “	0.762 “	0.801 “	0.841 “	0.881 “	0.924 “	0.962 “
19	0.763 “	0.804 “	0.845 “	0.887 “	0.928 “	0.975 “	1.015 “
19½	0.804 “	0.847 “	0.890 “	0.934 “	0.978 “	1.027 “	1.069 “
20	0.846 “	0.891 “	0.936 “	0.983 “	1.029 “	1.080 “	1.125 “
20½	0.888 “	0.936 “	0.984 “	1.032 “	1.081 “	1.134 “	1.181 “
21	0.932 “	0.982 “	1.032 “	1.083 “	1.134 “	1.191 “	1.240 “
22	1.023 “	1.078 “	1.133 “	1.189 “	1.245 “	1.307 “	1.361 “
23	1.118 “	1.178 “	1.238 “	1.300 “	1.361 “	1.428 “	1.487 “
28	1.657 “	1.745 “	1.835 “	1.926 “	2.017 “	2.117 “	2.204 “

For weight of steam used per revolution of drivers at full cutoff:—Multiply the tabular quantity by four times the length of stroke in feet for simple and four cylinder compounds. For two cylinder compounds multiply by two times the length of stroke.

(b) For simple locomotives using superheated steam.

Diameter of Cylinder in Inches	Weight of Steam per Foot of Stroke for Various Gage Pressures					
	160 lbs.	170 lbs.	180 lbs.	190 lbs.	200 lbs.	210 lbs.
18	.415	.443	.470	.498	.524	.551
19	.465	.496	.526	.557	.587	.618
20	.515	.549	.582	.617	.650	.684
21	.565	.605	.641	.679	.715	.752
22	.623	.665	.705	.747	.787	.827
23	.682	.728	.772	.818	.861	.905
24	.741	.791	.838	.889	.931	.984
25	.804	.859	.910	.965	1.016	1.065
26	.868	.927	.983	1.041	1.097	1.150
27	.937	1.000	1.057	1.123	1.183	1.241
28	1.008	1.078	1.143	1.209	1.275	1.340
29	1.083	1.156	1.225	1.299	1.368	1.438
30	1.157	1.234	1.308	1.387	1.460	1.533

This assumes a superheat of 200 degrees Fahrenheit, and a drop of 5 lbs. per square inch in pressure between the boilers and the cylinders.

TABLE 3

Values of Coefficient "*C*" for Changing Revolutions per Minute of Drivers Into Velocity in Miles per Hour.

$$``C" = \frac{336.13}{\text{Diameter of drivers in inches.}}$$

$$\text{Miles per hour} = \frac{\text{Revolutions per minute}}{``C"}$$

Diam.	"C"	Diam.	"C"	Diam.	"C"	Diam.	"C"
50 in.	6.72	58 in.	5.79	66 in.	5.09	74 in.	4.54
51 "	6.59	59 "	5.69	67 "	5.01	75 "	4.48
52 "	6.46	60 "	5.60	68 "	4.94	76 "	4.42
53 "	6.34	61 "	5.51	69 "	4.87	77 "	4.36
54 "	6.22	62 "	5.42	70 "	4.80	78 "	4.31
55 "	6.11	63 "	5.33	71 "	4.73	79 "	4.25
56 "	6.00	64 "	5.25	72 "	4.67	80 "	4.20
57 "	5.89	65 "	5.17	73 "	4.60	81 "	4.15

TABLE 4

POUNDS OF STEAM PER I. H. P. HOUR FOR VARIOUS MULTIPLES OF "*M*."

(a) For locomotives using saturated steam.

"*M*"=Maximum velocity in miles per hour at full cutoff.
Boiler pressure, 200 lbs.

Velocity	Pounds Steam per I. H. P. Hour		Velocity	Pounds Steam per I. H. P. Hour	
	Simple Locomotive	Compound Locomotive		Simple Locomotive	Compound Locomotive
1.0 M	38.30	25.80	2.9 M.	24.37	21.04
1.1 "	36.46	24.36	3.0 "	24.22	21.21
1.2 "	34.89	23.24	3.2 "	24.00	21.57
1.3 "	33.56	22.35	3.4 "	23.85	21.93
1.4 "	32.41	21.65	3.6 "	23.80	22.27
1.5 "	31.40	21.14	3.8 "	23.80	22.57
1.6 "	30.49	20.77	4.0 "	23.87	22.85
1.7 "	29.67	20.52	4.25 "	24.05	23.22
1.8 "	28.93	20.40	4.50 "	24.24	23.56
1.9 "	28.25	20.40	4.75 "	24.44	23.85
2.0 "	27.62	20.40	5.00 "	24.64	24.15
2.1 "	27.05	20.40	5.5 "	24.98	24.70
2.2 "	26.52	20.40	6.0 "	25.20	
2.3 "	26.06	20.40	6.5 "	25.45	
2.4 "	25.67	20.40	7.0 "	25.60	
2.5 "	25.32	20.47	7.5 "	25.70	
2.6 "	25.02	20.60	8.0 "	25.80	
2.7 "	24.76	20.73	9.0 "	25.90	
2.8 "	24.54	20.88			

For steam per I. H. P. hour for other boiler pressures take the following percentages of values given in table:

160 lbs., 103 per cent.	190 lbs., 100.6 per cent.
170 lbs., 102.1 per cent.	210 lbs., 99.5 per cent.
180 lbs., 101.3 per cent.	220 lbs., 99.2 per cent.

(b) For simple locomotives using superheated steam.

Velocity	Pounds of Steam Per I. H. P. Hour.	Velocity	Pounds of Steam Per I. H. P. Hour.
1.0 M	24.00	2.8 M	18.70
1.1 "	23.58	2.9 M	18.55
1.2 "	23.10	3.0 M	18.40
1.3 "	22.74	3.2 M	18.20
1.4 "	22.28	3.4 M	18.00
1.5 "	21.92	3.6 M	17.79
1.6 "	21.55	3.8 M	17.60
1.7 "	21.20	4.0 M	17.44
1.8 "	20.90	4.25 M	17.26
1.9 "	20.59	4.5 M	17.10
2.0 "	20.32	4.75 M	16.96
2.1 "	20.05	5.0 M	16.86
2.2 "	19.81	5.5 M	16.72
2.3 "	19.60	6.0 M	16.63
2.4 "	19.40	6.5 M	16.62
2.5 "	19.22	7.0 M	16.62
2.6 "	19.02	8.0 M	16.62
2.7 "	18.86		

TABLE 5

Per Cent. Cylinder Tractive Power for Various Multiples of "*M*."

"*M*"=Maximum Velocity in Miles per hour at which Boiler Pressure can be maintained with full cutoff.

(a) For locomotives using saturated steam.

Velocity	Compound per cent.	Simple per cent.	Velocity	Compound per cent.	Simple per cent.	Velocity	Compound per cent.	Simple per cent.
Start	(Simple) 135.00	106.00	3.6 M	32.40	44.75	6.4 M		23.59
0.5 M	103.00	103.00	3.7 "	31.25	43.56	6.5 "		23.18
1.0 "	100.00	100.00	3.8 "	30.10	42.39	6.6 "		22.79
1.1 "	96.28	95.57	3.9 "	29.14	41.24	6.7 "		22.42
1.2 "	92.55	91.53	4.0 "	28.24	40.10	6.8 "		22.06
1.3 "	88.83	87.83	4.1 "	27.38	39.00	6.9 "		21.71
1.4 "	85.12	84.46	4.2 "	26.56	37.96	7.0 "		21.38
1.5 "	81.40	81.37	4.3 "	25.77	36.97	7.1 "		21.06
1.6 "	77.68	78.55	4.4 "	25.03	36.03	7.2 "		20.75
1.7 "	73.96	75.97	4.5 "	24.34	35.13	7.3 "		20.45
1.8 "	70.25	73.60	4.6 "	23.69	34.26	7.4 "		20.16
1.9 "	66.54	71.41	4.7 "	23.07	33.41	7.5 "		19.88
2.0 "	63.21	69.37	4.8 "	22.48	32.59	7.6 "		19.61
2.1 "	60.20	67.47	4.9 "	21.92	31.82	7.7 "		19.34
2.2 "	57.48	65.67	5.0 "	21.38	31.11	7.8 "		19.08
2.3 "	54.97	63.94	5.1 "	20.87	30.42	7.9 "		18.82
2.4 "	52.68	62.22	5.2 "	20.37	29.75	8.0 "		18.57
2.5 "	50.42	60.55	5.3 "	19.89	29.10	8.1 "		18.33
2.6 "	48.16	58.92	5.4 "	19.43	28.48	8.2 "		18.09
2.7 "	46.08	57.33	5.5 "	18.99	27.87	8.3 "		17.86
2.8 "	44.10	55.78	5.6 "		27.33	8.4 "		17.64
2.9 "	42.29	54.26	5.7 "		26.81	8.5 "		17.43
3.0 "	40.57	52.78	5.8 "		26.30	8.6 "		17.22
3.1 "	38.95	51.33	5.9 "		25.81	8.7 "		17.01
3.2 "	37.42	49.91	6.0 "		25.34	8.8 "		16.82
3.3 "	35.98	48.55	6.1 "		24.88	8.9 "		16.63
3.4 "	34.66	47.24	6.2 "		24.44	9.0 "		16.45
3.5 "	33.53	45.97	6.3 "		24.01			

(b) For simple locomotives using superheated steam.

Velocity	Per Cent	Velocity	Per Cent	Velocity	Per Cent	Velocity	Per Cent
Start	106.00	2.7 M	47.12	4.5 M	31.19	6.3 M	22.90
0.5 M	103.00	2.8 M	45.82	4.6 M	30.61	6.4 M	22.56
1.0 M	100.00	2.9 M	44.61	4.7 M	30.05	6.5 M	22.21
1.1 M	92.42	3.0 M	43.49	4.8 M	29.52	6.6 M	21.89
1.2 M	86.55	3.1 M	42.30	4.9 M	29.00	6.7 M	21.57
1.3 M	81.20	3.2 M	41.21	5.0 M	28.48	6.8 M	21.24
1.4 M	76.95	3.3 M	40.17	5.1 M	27.96	6.9 M	20.92
1.5 M	73.00	3.4 M	39.22	5.2 M	27.47	7.0 M	20.62
1.6 M	69.55	3.5 M	38.30	5.3 M	27.00	7.1 M	20.32
1.7 M	66.60	3.6 M	37.42	5.4 M	26.53	7.2 M	20.07
1.8 M	63.66	3.7 M	36.61	5.5 M	26.10	7.3 M	19.78
1.9 M	61.27	3.8 M	35.89	5.6 N	25.69	7.4 M	19.52
2.0 M	58.96	3.9 M	35.11	5.7 M	25.26	7.5 M	19.26
2.1 M	56.94	4.0 M	34.39	5.8 M	24.86	7.6 M	19.01
2.2 M	55.12	4.1 M	33.72	5.9 M	24.46	7.7 M	18.76
2.3 M	53.26	4.2 M	33.06	6.0 M	24.04	7.8 M	18.52
2.4 M	51.53	4.3 M	32.40	6.1 M	23.66	7.9 M	18.28
2.5 M	49.98	4.4 M	31.79	6.2 M	23.28	8.0 M	18.06
2.6 M	48.50						

TABLE 6

Pounds Tractive Power for One Horsepower at Various Speeds.

Formula: $\text{One H. P.} = \dfrac{375}{\text{Velocity in miles per hour}}$

Velocity	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3	125.0	120.97	117.19	113.64	110.29	107.14	104.17	101.35	98.68	96.15
4	93.75	91.46	89.29	87.21	85.23	83.33	81.52	79.79	78.13	76.53
5	75.00	73.53	72.12	70.75	69.44	68.18	66.96	65.79	64.66	63.56
6	62.50	61.48	60.48	59.52	58.59	57.69	56.82	55.97	55.15	54.35
7	53.57	52.82	52.08	51.37	50.68	50.00	49.34	48.70	48.08	47.47
8	46.88	46.30	45.74	45.18	44.64	44.12	43.60	43.10	42.61	42.13
9	41.67	41.21	40.76	40.32	39.89	39.47	39.06	38.66	38.27	37.88
10	37.50	37.13	36.77	36.41	36.06	35.71	35.38	35.05	34.72	34.40
11	34.09	33.78	33.48	33.19	32.89	32.61	32.33	32.05	31.78	31.51
12	31.25	30.99	30.74	30.49	30.24	30.00	29.76	29.53	29.30	29.07
13	28.85	28.63	28.41	28.20	27.99	27.78	27.57	27.37	27.17	26.98
14	26.79	26.60	26.41	26.22	26.04	25.86	25.68	25.51	25.34	25.17
15	25.00	24.83	24.67	24.51	24.35	24.19	24.04	23.88	23.73	23.58
16	23.44	23.29	23.15	23.01	22.87	22.73	22.59	22.46	22.32	22.19
17	22.06	21.93	21.80	21.68	21.55	21.43	21.31	21.19	21.07	20.95
18	20.83	20.72	20.60	20.49	20.38	20.27	20.16	20.05	19.95	19.84
19	19.74	19.63	19.53	19.43	19.33	19.23	19.13	19.03	18.94	18.84
20	18.75	18.66	18.56	18.47	18.38	18.29	18.20	18.12	18.03	17.94
21	17.86	17.77	17.69	17.61	17.52	17.44	17.36	17.28	17.20	17.12
22	17.05	16.97	16.89	16.82	16.74	16.67	16.59	16.52	16.45	16.37
23	16.30	16.23	16.16	16.09	16.03	15.96	15.89	15.82	15.76	15.69
24	15.63	15.56	15.50	15.43	15.37	15.31	15.24	15.18	15.12	15.06
25	15.00	14.94	14.88	14.82	14.76	14.71	14.65	14.59	14.53	14.48
26	14.42	14.37	14.31	14.26	14.20	14.15	14.10	14.04	13.99	13.94
27	13.89	13.84	13.79	13.74	13.68	13.63	13.59	13.54	13.49	13.44
28	13.39	13.35	13.30	13.25	13.20	13.16	13.11	13.07	13.02	12.98
29	12.93	12.89	12.84	12.80	12.76	12.71	12.67	12.63	12.58	12.54
30	12.50	12.46	12.42	12.38	12.34	12.30	12.26	12.22	12.18	12.14
31	12.10	12.06	12.02	11.98	11.94	11.90	11.87	11.83	11.79	11.76
32	11.72	11.68	11.65	11.61	11.57	11.54	11.50	11.47	11.43	11.40
33	11.36	11.33	11.30	11.26	11.23	11.19	11.16	11.13	11.09	11.06
34	11.03	11.00	10.96	10.93	10.90	10.87	10.84	10.81	10.78	10.74
35	10.71	10.68	10.65	10.62	10.59	10.56	10.53	10.50	10.47	10.44
36	10.42	10.39	10.36	10.33	10.30	10.27	10.24	10.21	10.18	10.16

For intermediate velocities, values per horsepower can be found by interpolation.

TABLE 7

LOCOMOTIVE RESISTANCES.

Ⓐ Cylinder to Rim of Drivers:
Total Pounds $R=18.7T+80N$.
T=Tons Weight on Drivers.
N=Number Driving Axles.

Ⓑ Engine and Tender Trucks:
Total Pounds $R=2.6T+20N$.
T=Tons Weight on Engine and Tender Trucks.
N=Number of Truck Axles.

Ⓒ Head End or "Air" Resistance.
$R=.002V^2A$;......
V=Velocity in Miles per Hour.
A=Area (Average for Locomotives, 125 sq. ft.).

Total $R=0.25V^2$.

Air Resistance (C) for Various Velocities.

Velocity	R	Velocity	R	Velocity	R	Velocity	R
1	0.25	11	30	21	110	31	240
2	1.00	12	36	22	121	32	256
3	2.25	13	42	23	132	33	272
4	4.00	14	49	24	144	34	289
5	6.25	15	56	25	156	35	306
6	9.00	16	64	26	169	36	324
7	12.25	17	72	27	182	37	342
8	16.00	18	81	28	196	38	361
9	20.25	19	90	29	210	39	380
10	25.00	20	100	30	225	40	400

Drawbar pull on level tangent equals the cylinder Tractive Power less the sum of Engine Resistances.

At Low Speeds the adhesion of drivers should be considered and available drawbar pull should never be estimated greater than 30 per cent. of Weight on Drivers at starting with use of sand, 25 per cent. of Weight on Drivers at running speeds.

[3]TRAIN RESISTANCE.

(1) Dynamometer tests to be of the greatest value should show the following:

(a) Dynamometer record (graphical) showing drawbar pull to nearest ten pounds, with horizontal scale not less than 400 feet to one inch and in special cases a larger scale.

(b) Speed record to nearest tenth of mile per hour (graphical).

(c) Key to record mile posts.

(d) Condition of track surface and gage (graphical).

(e) Steam pressure of boiler (graphical).

(f) Train line air pressure (graphical).

(g) Time record (graphical).

(Speed record may be independent record, and in this case time record is desirable.)

(h) Coal consumption (record of shovels of coal as used) (worked by hand in engine).

Requisite data to be taken:

TRACK.

(i) Office profile and alinement connecting with mile posts (so as to connect with 3).

(j) Section of rail.

(k) Condition of rail.

(l) Number of ties to rail (and rail length).

(m) Kind and quantity of ballast.

LOCOMOTIVE.

(n) Type (wheel arrangement, whether simple or compound and dimensions of locomotive).

(o) Total weight and weight on drivers.

CARS.

(p) Record of length, initial, number, class of each car of train; also weight empty and weight loaded.

(q) Kind of truck.

(r) Condition of car.

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[3] Adopted, Vol. 11, Part 2, 1911, pp. 647-666, 715-731.

WEATHER.

(s) Temperature.

(t) Direction of force of wind and direction of train.

(u) State of weather (rain or clear).

(2) Numerous tests demonstrate that there is no absolute value for train resistance. For practical purposes freight train resistance can be considered constant between velocities of 7 and 35 miles per hour.

(3) The following formulas are practicable where train has been in motion at least fifteen minutes.

(a) Assuming—

A Rating is used at temperature of 35 degrees Fahrenheit,

B Rating is used at temperature between 20 degrees Fahrenheit and 35 degrees Fahrenheit,

C Rating is used at temperature between 0 degrees Fahrenheit and 20 degrees Fahrenheit.

D Rating is used at temperature below 0 degrees Fahrenheit; the following formulas are practical:

A Rating: $R = 2.2\ T + 122\ C$ (on level grade).
B Rating: $R = 3.0\ T + 137\ C$ (on level grade).
C Rating: $R = 4.0\ T + 153\ C$ (on level grade).
D Rating: $R = 5.4\ T + 171\ C$ (on level grade).

when $R =$ total resistance of train in pounds.
$T =$ tonnage of train in tons of 2000 pounds.
$C =$ the number of cars in the train.

(4) (a) Compensate .03 per degree:

When the length of curve is less than half the length of the longest train.

When a curve occurs within the first 20 feet of rise of a grade.

When curvature is in no sense limiting.

(b) Compensate .035 per degree:

When curves are between one-half and three-quarters as long as the longest train.

When the curve occurs between 20 feet and 40 feet of rise from the bottom of the grade.

(c) Compensate .04 per degree:

Where the curve is habitually operated at low speed.

Where the length of the curve is longer than three-quarters of the length of the longest train.

Where elevation is excessive for freight trains.

At all places where curvature is likely to be limiting.

(d) Compensate .05 per degree wherever the loss of elevation can be spared.

(5) Condition of roadway maintenance has a great effect on train resistance.

(6) Condition and design of equipment has a great effect on train resistance.

PERCENTAGE OF ADJUSTED RATING "B," "C" AND "D"
"A" RATING TAKEN AS 100%.

Per Cent. Grade	Adjustment	"B"	"C"	"D"
0.1	29	84	70	57
0.15	23	87	74	62
0.2	20	89	78	66
0.25	17	90	80	69
0.3	15	91	82	72
0.35	13	92	84	74
0.4	12	93	85	76
0.45	11	93	86	78
0.5	10	94	87	79
0.55	9	94	88	81
0.6	9	95	89	82
0.65	9	95	89	83
0.7	8	95	90	84
0.75	7	96	91	84
0.8	7	96	91	85
0.85	6	96	91	86
0.9	6	96	92	86
1.0	5	97	93	87
1.1	5	97	93	88
1.2	5	97	93	89
1.3	4	97	94	90
1.4	4	97	94	91
1.5	4	98	95	91
1.6	4	98	95	92
1.7	3	98	95	92
1.8	3	98	96	93
1.9	3	98	96	93
2.0	3	98	96	93
2.1	3	98	96	93
2.2	3	98	96	94
2.3	2	98	96	94
2.4	2	98	96	94
2.5	2	99	97	94
2.6	2	99	97	94
2.7	2	99	97	95
2.8	2	99	97	95
2.9	2	99	97	95
3.0	2	99	97	95

(7) Resistance of individual cars of same weight but of different type shows considerable variation. Sufficient data are not yet available to determine just how much the difference is.

(8) Starting resistance varies from 10 to 40 lbs. per ton, depending on loading, temperature and character of maintenance of roadway and equipment.

[4]CURVATURE.

(1) A straight line is the ideal alinement.

(2) The justifiable expenditure to eliminate one degree of central angle in the alinement of roadway depends largely on the number of daily trains and the cost per train per mile.

(3) As a general rule it is good practice to spend more money to take out one degree of central angle where the radius is small, requiring the maximum elevation of the outer rail, than where the radius is large requiring less elevation.

(4) As a general rule, it is justifiable to spend more money to take out one degree of central angle where train runs at a high rate of speed than where the speed is low.

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[4] Adopted, Vol. 11, Part 1, 1911, pp. 666-669, 732, 733.

COMMITTEE XVII.

WOOD PRESERVATION.

[1] GENERAL REQUIREMENTS.

(1) Creosote oil and zinc-chloride are effective wood preservatives when properly applied and when used under proper conditions.

(2) Accurate records should be kept in order to form proper conclusions as to the merit of different methods and processes.

(3) Preserved wood may be destroyed by mechanical action long before it is decayed, and therefore should be protected by economical devices when the mechanical life limits the life of the tie.

(4) There should be a standard temperature at which creosote oil is measured. The temperature of 100 degrees Fahrenheit is recommended.

(5) It is essential that timber should be properly grouped in order that a successful treatment may be obtained. The species, in proportion of heartwood and sapwood, condition of the timber with respect to its moisture content and the wood structure, will in general determine this grouping.

(6) It is desirable to air-season timber in order to prepare it for treatment. Most woods can be best treated after being air-seasoned.

(7) Chemicals used should be tested for purity from time to time. Either the chemists for the Company will do this themselves or indicate some simple tests which may be applied by operatives at the works.

(8) In operating with zinc-chloride, the strength of the solution should be varied from time to time to conform to the kind and condition of the ties, so as to inject the required quantities. But in no case should the strength of the solution exceed 5 per cent.

(9) It is better to inject quantities of the chemicals in excess of the requirements than to skimp the treatment in any way.

(10) Daily reports should be kept at the works, and duplicates sent to the general office, if desired, in order to check the operation.

(11) Ties treated with zinc-chloride should dry for some little time (to harden the outer surface) before they are put in the tracks. This

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[1] Adopted, Vol. 10, 1909, pp. 629-631, 669-676; Vol. 11, Part 2, 1910, pp. 737, 761, 859; Vol. 12, 1911.

is preferably done in piles, arranged to induce drying without checking as evaporation takes place.

(12) For best results it is recommended that certain sections of track be selected on each railroad for the purpose of making accurate tests covering the life of treated and untreated ties of various kinds of timber and under various treatments, and that an accurate record be kept of the life of all ties in these test sections of track in order to be able hereafter to improve on the treatment. All ties inserted in such test sections shall be marked with dating nails, and, if necessary, with their identification marks.

(13) In order to judge of the penetration of the oil, borings should be made with an augur, ¾ to 1 inch in diameter, in not less than six ties in each cylinder load. The holes should be plugged with creosoted turned plugs of diameter $\frac{1}{16}$-inch larger than the holes.

(14) Bridge material intended for treatment should be framed, as far as possible, before timbers are placed in the treating cylinder. This includes the boring of the necessary holes.

[2] GROUPING OF TIMBERS FOR ANTISEPTIC TREATMENT.

(1) Ties of approximately the same period of seasoning should be grouped together for treatment; green ties should never be mixed with seasoned ones.

(2) Pine ties should be separated on the basis of heartwood and sapwood; it would also be advisable in some cases to group hardwoods on the same basis, but it is not generally practical to do so.

(3) Grouping on the basis of species and families, as, for example, red oaks, pine, beech, etc., if a further division into heartwood classes is made with pine, is usually a satisfactory practice. From this it follows that red oak, beech, longleaf pine, loblolly pine and gum should be treated separately. Birch and hard maples and certain other combinations, depending on the locality, can be grouped together to advantage.

(4) The separation in the yard, on the basis the ties are to be grouped for treatment, is an essential and economical practice.

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[2] Adopted, Vol. 13, 1912, pp. 864, 1040-1041.

[3] SPECIFICATIONS FOR CREOSOTE OIL.

STANDARD SPECIFICATIONS FOR CREOSOTE OIL.

The oil used shall be the best obtainable grade of coal-tar creosote; that is, it shall be a pure product obtained from coal gas tar or coke oven tar and shall be free from any tar, including coal gas tar and coke oven tar, oil or residue obtained from pertoleum or any other source; it shall be completely liquid at 38 degrees Centigrade and shall be free from suspended matter; the specific gravity of the oil at 38 degrees Centigrade shall be at least 1.03. When distilled by the common method—that is, using an 8-ounce retort, asbestos covered, with standard thermometer, bulb ½-inch above the surface of the oil—the creosote, calculated on the basis of the dry oil, shall give no distillate below 200 degrees Centigrade, not more than 5 per cent. below 210 degrees Centigrade, not more than 25 per cent. below 235 degrees Centigrade, and the residue above 355 degrees Centigrade, if it exceeds 5 per cent. in quantity, shall be soft. The oil shall not contain more than 3 per cent. water.

Note.—*In addition to the above standard specification, the two following grades can be used in cases where the higher grade oil cannot be procured. It should be understood that where it is necessary to purchase grades No. 2 and No. 3 consideration should be given to the use of a greater quantity of creosote oil per cubic foot.*

SPECIFICATIONS FOR NO. 2 GRADE CREOSOTE OIL.

The oil used shall be the best obtainable grade of coal-tar creosote; that is, it shall be a pure product obtained from coal gas tar or coke oven tar, and shall be free from any tar, including coal gas tar and coke oven tar, oil or residue obtained from petroleum or any other source; it shall be completely liquid at 38 degrees Centigrade and shall be free from suspended matter; the specific gravity of the oil at 38 degrees Centigrade shall be at least 1.03. When distilled by the common method—that is, using an 8-ounce retort, asbestos covered, with standard thermometer, bulb ½-inch above the surface of the oil—the creosote, calculated on the basis of the dry oil, shall give not more than 8 per cent. distillate below 210 degrees Centigrade, not more than 35 per cent. below 235 degrees Centigrade, and the residue above 355 degrees Centigrade, if it exceeds

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[3] Adopted, Vol. 13, 1912, pp. 865-866, 1042-1051.

5 per cent. in quantity, shall be soft. The oil shall not contain more than three per cent. water.

SPECIFICATIONS FOR NO. 3 GRADE CREOSOTE OIL.

The oil shall be the best obtainable grade of coal-tar creosote; that is, it shall be a pure product obtained from coal gas tar or coke oven tar and shall be free from any tar, including coal gas tar and coke oven tar, oil or residue obtained from petroleum or any other source; it shall be completely liquid at 38 degrees Centigrade and shall be free from suspended matter; the specific gravity of the oil at 38 degrees Centigrade shall be at least 1.025. When distilled by the common method—that is, using an 8-ounce retort, asbestos covered, with standard thermometer, bulb ½-inch above the surface of the oil—the creosote, calculated on the basis of the dry oil, shall give not more than 10 per cent. distillate below 210 degrees Centigrade, not more than 40 per cent. below 235 degrees Centigrade, and the residue above 355 degrees Centigrade, if it exceeds 5 per cent. in quantity, shall be soft. The oil shall not contain more than 3 per cent. water.

[4] SPECIFICATIONS FOR THE FRACTIONATION OF CREOSOTE OIL.

1. The sample taken for analysis shall be strictly average of the whole bulk of oil to be tested. The oil shall be completely liquefied and well mixed before samples are taken. Whenever possible a drip sample of not less than two gallons shall be taken commencing after the oil has started to run freely. When this cannot be done, as for instance, in large storage tanks, samples shall be taken from various depths in the tank by means of a tube or bottle, the number of samples depending on local conditions.

For taking samples during the process of treatment a sample of the oil shall be taken from the storage tank about one foot from the bottom of the tank before the cylinder is filled, and, where possible, a sample directly from the cylinder during the process of treatment. For this purpose a thermometer well, as shown in diagram, may be used.

The sample to be analyzed shall be thoroughly liquefied by heating until no crystals adhere to a glass stirring rod, and also well shaken,

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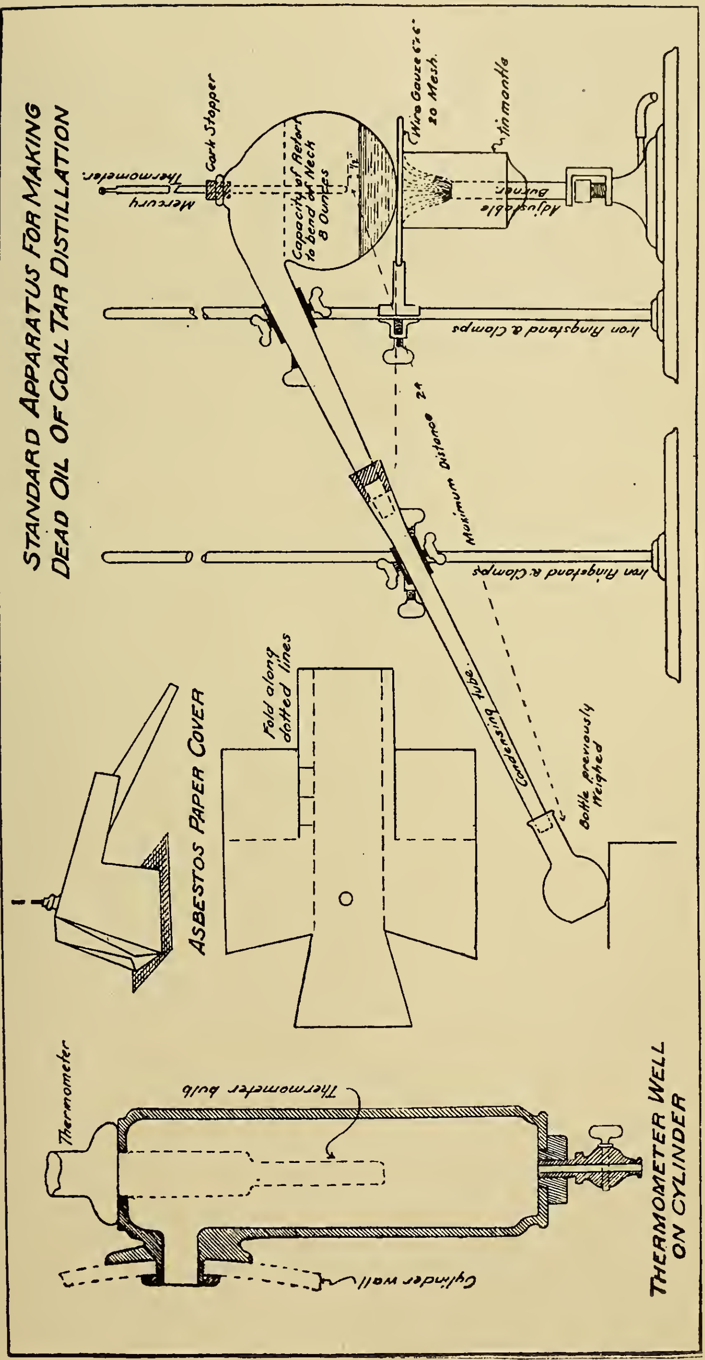
[4] Adopted, Vol. 9, 1908, pp. 708-711, 768; Vol. 11, Part 2, 1911, pp. 743-746, 860; Vol. 13, 1912, pp. 867, 1051.



STANDARD APPARATUS FOR MAKING DEAD OIL OF COAL TAR DISTILLATION

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THERMOMETER WELL ON CYLINDER

after which one-half shall be taken for analysis and the balance reserved as a check test.

2. The apparatus for distilling the creosote shall consist of a stoppered glass retort similar to that shown in diagram having a capacity as nearly as can be obtained of eight ounces up to the bend of the neck when the bottom of the retort and the mouth of the off-take are in the same plane. A nitrogen filled mercury thermometer of good standard make, divided into full degrees Centigrade, shall be used in connection therewith. In order to insure uniform results for comparative purposes, the length of the thermometer bulb shall be ½-inch; but in no case shall a thermometer with a long bulb be used. The bulb of the retort and at least 2 inches of the neck shall be and remain covered with a shield of heavy asbestos paper, shaped as shown in diagram, during the entire process of distillation, so as to prevent heat radiation. Between the bottom of the retort and the flame of the lamp or burner two sheets of wire gauze, each 20-mesh fine, and at least 6 inches square, shall be placed.

The flame shall be protected against air currents. An ordinary tin can, from which a portion of the bottom and all of the top have been removed, placed on a support attached to the burner, as shown in diagram, will answer the purpose.

3. Before beginning the distillation the retort shall be carefully weighed and exactly one hundred grammes of oil placed therein, the same being weighed in the retort. The thermometer shall be inserted in the retort with the lower end of the bulb one-half inch from the surface of the oil and the condensing tube attached to the retort by a tight cork joint. The distance between the bulb of the thermometer and the end of the condensing tube shall not be less than 20 nor more than 24 inches, and during the process of the distillation the thermometer shall remain in the position in which it was originally placed.

The distillate shall be collected in weighed bottles and all fractions determined by weight. Reports shall be made on the following fractions:

0 to 170 degrees Centigrade.
170 to 200 degrees Centigrade.
200 to 210 degrees Centigrade.
210 to 235 degrees Centigrade.
235 to 270 degrees Centigrade.
270 to 315 degrees Centigrade.
315 to 355 degrees Centigrade.
Residue above 355 degrees Centigrade.

Reports shall be made on individual fractions. In making such reports it is to be distinctly understood that these fractions do not necessarily refer to individual compounds. In other words, the fraction between 210 and 235 degrees will not necessarily be all naphthalene, but will probably contain a number of other compounds.

The distillation shall be continuous, and should require about forty-five minutes.

When any measurable quantity of water is present in the oil the distillation shall be stopped, the oil separated from the water and returned to the retort, when the distillation shall be recommenced and the previous readings discarded. In obtaining water-free oil, it is desirable to free about 300 to 600 cc. of the oil by using a large retort and 100 grammes of the water-free oil for the final distillation. In the final report as to fractions, a correction shall be made of the amount of water remaining, so that the report may be made on the basis of a dry oil.

4. In order to determine the specific gravity of any oil, simply heat the oil in a water bath until it is completely liquefied. A glass stirring rod dipped into the liquid should show no solid particle on the rod when the same is withdrawn from the oil. When completely liquefied, it should be stirred thoroughly and the hydrometer cylinder filled, which has previously been warmed. Insert a specific gravity hydrometer of good make, taking care that the hydrometer does not touch the sides or bottom of the cylinder when the reading is taken. This reading should preferably be taken when the oil is at 38 degrees Centigrade (100 degrees Fahrenheit), because at this temperature almost all oils are completely fluid. Where contract requirements specify a specific gravity at a different temperature, such gravity is obtained by multiplying .0008 by the number of degrees Centigrade, or .00044 by the number of degrees Fahrenheit, the oil is found to be above the temperature required by the contract, and adding the product to the observed gravity.

If it is desired to make further chemical analysis for the determination of the low-boiling tar acids and the naphthalene, the following method is recommended, tentatively:

For the determination of low-boiling tar acids, the fractions should be placed in a separating funnel, to which should be added about 30 cc. of the 15 per cent. hot sodium hydroxide solution, vigorously shaken, and allowed to stand until the dissolved phenols separate and are drawn off; after which repeat with successive sodium hydroxide solutions 20 cc. each time until no phenols are left (the sodium solution comes off clear).

The phenols so obtained should be separated by the addition of a 25 per cent. sulphuric acid, slowly stirred in. When this reaction is complete, the phenols so obtained should be decanted and weighed.

The fractions remaining after extracting the phenols from the distillate should be placed in a conical vessel, such as a graduate, and surrounded by a freezing mixture of ice and salt, and allowed to remain until completely frozen. The naphthalenes so frozen should be chopped up with a knife or mashed and placed in a small brass cylinder about 1½ inches in diameter by 4 inches long, open at both ends, but fitted with small brass plates or plugs. Before putting the naphthalene in, place several thicknesses of blotting paper, cut to fit the cylinder on the bottom plate, and before putting in the top plate introduce similar blotting pads. Place several sheets of blotting pads on the plate of a copy press, put the cylinder so charged in the press and apply pressure to the top plate or plug, leaving it for about one hour. A plug of clean white naphthalene is the result, and may be taken out and weighed.

[5] THE USE OF COAL TAR IN CREOSOTE.

(1) Wherever possible only Grade 1 Coal Tar Creosote should be used, and under no circumstances should coal tar be added to creosote of this grade.

[6] SPECIFICATIONS FOR CREOSOTE-COAL TAR SOLUTION.

This specification is submitted for the guidance of those desiring to use the coal tar addition to creosote, which practice is firmly established and widely followed. The creosote-coal tar solution is not recommended as equal to creosote in preservative qualities, and should be used only when the available supply of creosote is inadequate.

1. The oil shall be a pure coal-tar product, consisting only of coal-tar distillates and oils obtained by the filtration of coal-tar. It shall contain no admixture of crude tar.

2. Water shall not exceed 2 per cent.

3. Specific gravity at 38 degrees Centigrade shall not be less than 1.03, nor more than 1.10.

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[5] Adopted, Vol. 15, pp. 632, 1093, 1094.

[6] Adopted, Vol. 16, 1915, pp. 826, 1154.

4. Matter insoluble in hot extraction with benzol shall not exceed 2 per cent.

5. The specific viscocity (Engler) at 82.3 degrees Centigrade (180 degrees Fahrenheit) shall be not more than 1.170 for 200 cc. No variation above this standard shall be allowed. The term "Specific Gravity" in this case shall mean the number of seconds for water at 20 degrees Centigrade given in the official certificate for the viscosimeter used.

6. On distillation by the standard method of the American Railway Engineering Association, it shall yield the following fractions based on dry oil:

Not more than 1 per cent. at 170 degrees Centigrade.
Not more than 5 per cent. at 210 degrees Centigrade.
Not more than 30 per cent. at 235 degrees Centigrade.
The residue at 355 degrees Centigrade shall not exceed 26 per cent.

[7] THE INSPECTION AND ANALYSIS OF THE COAL-TAR.

(1) The refined coal-tar used shall be subject to inspection or analysis by the Railway Company at any time, such examination to be permitted upon request prior to the mixing of the solution. This is for the reason that the determination of the quality of the coal-tar after its addition to the creosote is difficult, if not impossible.

(2) In case the Railway Company makes its own solution of coal tar and creosote, using crude tar for this purpose, it shall specify clearly as to the quality of the tar.

[8] PRECAUTIONS TO BE FOLLOWED IN THE USE OF THE CREOSOTE-COAL TAR SOLUTION.

(1) There should be a distinct understanding between all concerned that a mixture is specified and used.

(2) The coal-tar may be added to the creosote at treating plants when suitable facilities for properly mixing the solution are available; otherwise the solution should be mixed by the manufacturer, but subject to the inspection or supervision of the Railway Company.

(3) Under no circumstances should the coal-tar added constitute more than 25 per cent. of the mixture.

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[7] Adopted, Vol. 16, 1915, pp. 826, 1154.

[8] Adopted, Vol. 16, 1915, pp. 827, 1156.

(4) The coal-tar and creosote should be thoroughly mixed at a temperature of approximately 180 degrees Fahrenheit before being applied to the timber. The mixing should be done in tanks other than the regular working tanks, and the tanks containing the mixture should be heated and agitated thoroughly each time before any oil is transferred to the working tanks.

(5) Only low-carbon coal-tar should be used, the amount of free carbon not to exceed 5 per cent.

(6) In treating with the mixture the temperature of the solution in the cylinder should be not less than 180 degrees Fahrenheit.

[9] METHODS OF ACCURATELY DETERMINING THE ABSORPTION OF CREOSOTE OIL.

(1) At railroad plants the absorption should be based on the treatment which will give the most complete penetration for each class or kind of timber, specifying complete penetration of the sapwood and as much of the heart as possible for the particular species or charge; payment to be based on the amount of oil used, plus operating and other charges.

(2) Where railroads have their work done by contract, gallons should be specified for ties, posts, cross-arms and other material of uniform size, and pounds per cubic foot for other material; the same requirements as to sap and heart penetration to be applied as in the above.

[10] WATER IN CREOSOTE.

Allowable Limits of Water.

(1) The use of creosote in treatment containing up to 3 per cent. water is permissible. Where the quantity exceeds 3 per cent. proper allowance should be made, but under no circumstances shall timbers be treated with oils having more than 6 per cent. water.

Measurement of Oil.

(2) In all cases where water separates from the oil in the tank or car, the water should be taken off to as great an extent as practicable and the oil measurement then should be made from the point of sepa-

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[9] Adopted, Vol. 15, 1914, pp. 632, 1088.

[10] Adopted, Vol. 15, 1914, pp. 632, 1088.

ration between the remaining water and oil as nearly as this can be determined. This refers to the physical process of measurement.

Sampling of Oil for Water Content.

(3) In sampling oil a drip sample should be used in taking samples from cylinders during treatment, and an approved cross-section tube should be used for taking samples from tanks or tank cars.

Storage Tanks.

(4) All storage tanks should have a watertight roof.

[11]SPECIFICATIONS FOR TIE TREATMENT.

GENERAL REQUIREMENTS.

The General Requirements apply to each of the following treatments. If used in specifications for the purchase of ties or for treatment, then these General Requirements should be followed only by the particular treatment desired.

1. Ties shall not be treated until air-seasoned. If they arrive at the treating plant in a seasoned condition ready to treat, they may be loaded direct from the cars to the tram buggies; otherwise they shall be piled on the ground in their respective groups or classes, green ties separate from partially seasoned and from seasoned ties, and all resting on treated stringers, with not less than 6 inches air space between bottom of lowest tier and ground; the spaces under, between and around the piles shall be thoroughly drained, and at all times kept clear of weeds, high grass and decaying matter. The top tier shall be laid sloping to form a water shed. Especial attention should be given to keeping all decayed wood out of the yard and away from the ties. Ties shall be piled either 8 by 1 or 8 by 2 or in any other manner adapted to secure rapid and uniform seasoning with minimum checking. Alleys must be left between piles with 4 feet clear space in one direction and one foot in the other direction. These alleys will, in general, provide for uniform and fairly rapid seasoning.

Since the seasoning varies with the latitude, time of year, the exposure, and peculiarities of the season, it is best to establish by experiment the weight per cubic foot at which each class of timber will best receive the treatment, and then to weigh from time to time to determine when the timber is ready for treatment. Ties piled for seasoning shall be closely watched, and not allowed to over-season or to deteriorate.

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[11] Adopted, Vol. 8, 1907, pp. 476-480, 520; Vol. 11, Part 2, 1910, pp. 737-743, 761, 858-860.

Ties treated in the same run shall be as nearly as possible uniform in character of timber and degrees of seasoning. They shall, so far as practicable, be treated in order of their cutting, and shall be separated into groups according to their permeability, as ascertained by experiment. No ties shall be put into the cylinder which do not conform to the requirements of the tie specifications as to shakes, checks, etc. Ties which show signs of checking should be provided with "S" irons, bolts or other devices, in order to prevent, during or after treatment, further checking that would be liable to render them worthless. Where ties are to be adzed or bored for subsequent insertion of tie-plates or screw-spikes, such adzing and boring shall in all cases be done before treatment.

Thoroughly air-seasoned ties shall be placed in the cylinder and a preliminary vacuum of not less than 24 inches of mercury produced and maintained for a period of time not less than ten minutes, at the expiration of which the preservative shall be admitted without breaking the vacuum.

2. When ties that are not thoroughly air-seasoned must be treated, and are to be treated with metallic salts, the ties shall be placed in cylinders, the door closed and live steam admitted at such rate as to secure 20 lbs. of steam pressure within 30 to 50 minutes, as shown by gage connected to the cylinder. This pressure shall be maintained for periods varying from one to five hours, depending upon the character of the timber and its condition; but the pressure as indicated on the gage shall at no time be allowed to exceed 20 lbs. During the process of steaming a vent shall be kept open in the bottom of the cylinder or in the drain therefrom to permit the escape of air and the condensed water in the cylinder.

When ties that are not seasoned must be treated, and are to be treated with creosote, either long steaming or seasoning in hot creosote oil within safe limits of heat, as determined by experience, may be resorted to.

When the steaming is completed the steam shall be blown off, and a vacuum of not less than 24 inches of mercury produced, if the works are located at sea level; or a corresponding degree of vacuum produced at higher altitude. This vacuum shall be maintained for at least one-half hour, at the expiration of which time the preservative shall be admitted without otherwise breaking the vacuum.

ZINC-CHLORIDE TREATMENT.

The zinc-chloride solution shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to ½-lb. of dry soluble zinc-chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than 5 per cent. The solution shall be heated to a temperature of not less than 140 degrees Fahrenheit before admission to the cylinder. If the cylinders are provided with steam coils, steam pressure shall be maintained in these coils during treatment

The cylinder shall be entirely filled with preservative, and so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

The zinc-chloride used shall be as free from impurities of any kind as is practicable, being slightly basic, free from free acid, containing not more than 0.25 per cent. iron. The amount of chloride specified to be injected shall be of soluble zinc-chloride only. The amount of solution absorbed shall be determined by calculation based on the gage readings of the tank holding the supply of solution. This should be checked occasionally by weighing the ties loaded on the cylinder tram cars, before and after treatment, a scale being inserted in the tracks. The strength of the zinc-chloride solution shall be carefully controlled from time to time by hydrometer readings. Borings shall be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc-chloride according to the standard method made. The holes made in taking these borings shall be plugged tightly and completely with creosoted plugs.

ZINC-TANNIN TREATMENT.

The zinc-chloride solution shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to ½-lb. of dry soluble zinc-chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than 5 per cent.

The solution shall be heated to a temperature of not less than 140 degrees Fahrenheit before admission to the cylinder. If the cylinders are provided with steam coils, steam shall be maintained in these coils during the entire treatment.

The cylinder shall be entirely filled with preservative, and so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

After the required amount of zinc-chloride has been injected, this solution shall be run off and the ties allowed to drain for 15 minutes. The chloride draining off shall be blown or run off, and a 2 per cent. solution of tannic acid, made by mixing 6⅔ lbs. of 30 per cent. extract of tannin with 100 lbs. of water, run in, and a pressure of 100 lbs. produced and maintained one-half hour. This shall then be run off, a 1 per cent. solution of glue (made by dissolving 2-1/10 lbs. of glue containing 50 per cent. gelatine in 100 lbs. water) shall be admitted to the cylinder, and a pressure of 100 lbs. produced and maintained for one-half hour. Care shall be taken to maintain the solution containing the glue and tannic acid up to their organized strength in these elements.

The zinc-chloride used shall be as free from all impurities of any kind as is practicable, being slightly basic, free from free acid, containing not more than 0.25 per cent. iron. The amount of chloride specified to be injected shall be of soluble zinc-chloride only. The amount of solution absorbed shall be determined by calculation based on the gage readings of the tank holding the supply of solution. This should be checked occasionally by weighing the ties loaded on the cylinder tram cars, before and after treatment, a scale being inserted in the tram tracks. The strength of the zinc-chloride solution shall be carefully controlled from time to time by hydrometer readings. Borings shall be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc-chloride according to the standard method made. The holes made in taking these borings shall be plugged tightly and completely with creosoted plugs.

PLAIN CREOSOTING.

The creosote oil shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of oil to be injected shall be that provided for in the contract. Creosote oil shall be heated to a temperature of not less than 160 degrees Fahrenheit before admission to the cylinder. Cylinders shall be provided with sufficient steam coils to fully maintain this temperature during injection.

The cylinder shall be entirely filled with preservative, so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

The creosote oil shall comply with the standard specifications therefor, as determined by standard method of analysis. The amount of oil absorbed shall be determined by calculation based upon gage readings taken on the same tank before the introduction of the oil into the cylinder and after forcing back the oil after treatment. This should be checked occasionally by weighing the ties loaded on the cylinder tram cars before and after treatment, a scale being inserted in the tram tracks.

Daily reports of the injections shall be made. At least once a week an account of stock shall be taken and balance established to check the reported amounts used.

In making all measurements the oil should be at a constant temperature, or they should be reduced to a constant temperature by a proper reduction factor.

The oil shall be analyzed when received at the works; the samples being taken in the manner prescribed by the specifications for analysis of the oil. At least once during each week samples of oil shall be taken from the cylinders during the treatment and analyzed to determine if the water in the oil exceeds the limit in the specifications. If so, a correspondingly greater amount shall be injected. If this amount of water exceeds 6 per cent. steps shall be taken before it is used to remove the water, so as to bring the oil within the limits of the specifications.

ZINC-CREOSOTE EMULSION TREATMENT.

An emulsion of zinc-chloride and suitable creosote oil, the latter being at least 10 per cent. of the whole, shall be admitted. Adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of solution injected shall be such as to leave in the wood an equivalent of 4/10-lb. of dry soluble zinc-chloride and from 1¼ to 1½ lbs. of creosote per cubic foot on the average.

The zinc-chloride used shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than 3½ per cent. It shall be as free from impurities as is practicable, free from free acid and containing not more than 0.25 per cent. of iron. The creosote oil used shall be as nearly as possible of the same specific gravity as the zinc-chloride solution. It should generally conform to the standard specifications for creosote of this Association, except that it should preferably contain a large percentage of tar acids and a small percentage of naphthalene. To insure as perfect a mixture of the emulsion of the zinc-chloride solution with the creosote oil as possible, an effective stirring apparatus must be used in the storage tank, and preferably also in the cylinder. The emulsion shall be heated to a temperature of not less than 140 degrees Fahrenheit before admission to the cylinder, and if the latter is provided with steam coils, pressure shall be maintained in these coils during treatments.

The cylinder shall be entirely filled with preservative, and so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

Hydraulic pressure of 100 lbs. per square inch shall be applied upon the emulsion in the cylinder and shall be maintained until the required amounts are injected as above specified. The amount absorbed shall be determined by calculations based upon gage readings, both before the introduction of the emulsion into the cylinder and after forcing it back after treatment. This should be checked occasionally by weighing the ties loaded on the cylinder tram cars, before and after treatment, a scale being inserted in tram tracks. Daily reports of the injections shall be made, and at least once a week an account of stock shall be taken and balance established to check the reported amounts used. In making all measurements the oil should be at a constant temperature, or the measurements should be reduced to a constant temperature by a proper reduction factor.

TWO-INJECTION ZINC CREOSOTE.

The zinc-chloride solution shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to 3/10-lb. of dry soluble zinc-chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than 5 per cent. The solution shall be heated to a temperature of not less than 140 degrees Fahrenheit before admission to the cylinder.

The cylinder shall be entirely filled with preservative, so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

The zinc-chloride used shall be free from all impurities of any kind as is practicable, being slightly basic, free from free acid, and containing not more than 0.25 per cent. iron.

The solution of zinc-chloride shall then be run out, and creosote oil immediately admitted to the cylinder, adequate pressure applied, and oil injected into the ties to the average amount of 3 lbs. of oil per cubic foot of timber. The oil shall be heated to a temperature of not less than 140 degrees Fahrenheit before admission to the cylinder. Cylinders must be provided with sufficient steam coils to fully maintain the temperature during injection, and steam shall be maintained in the coils also during injection of the zinc-chloride and during vacuum. The creosote oil shall comply with the standard specifications therefor, as determined by standard method of analysis. The amount of oil absorbed shall be determined by calculation based upon gage readings taken before the introduction of the oil into the cylinder, and after forcing back the oil after treatment.

Daily reports of injections shall be made, and at least once a week an account of stock shall be taken, and balance established, to check the reported amounts used.

In making all measurements the oil should be at a constant temperature or they should be reduced to a constant temperature by a proper reduction factor.

The oil shall be analyzed when received at the works; the samples being taken in the manner prescribed by the specifications for oil. At least once during each week samples of oil shall be taken from the cylinders during treatment and analyzed to determine if the water in the oil exceeds the limits of the specifications. If so, a correspondingly greater amount of oil shall be injected. If the amount of water exceeds 6 per cent., steps shall be taken before it is used to remove the water, so as to bring the oil within the limits of the specifications.

[12] DETERMINATION OF ZINC IN TREATED TIMBERS.

NOTE.—*It is suggested that this method be applied by a Chemist.*

Taking Samples.

(1) The tools necessary for taking samples are a cross-cut saw and a one-inch auger. These should be wiped perfectly clean each time before taking a sample, in order to avoid contaminating the samples.

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[12] Adopted, Vol. 9, 1908, pp. 712-714, 768; Vol. 11, Part 2, 1911, pp. 746, 747, 860.

(2) The timbers from which samples are to be taken for analysis should be selected before the charge is loaded, and carefully weighed individually. They should be of average size and comparatively free from knots. After treatment they should be weighed and then piled until the dripping has stopped, when the samples may be taken.

(3) For ordinary determinations, timbers such as ties should be sawed at two points, viz., two feet from the end and at the center of the tie. These sections should be designated Section No. 1 and Section No. 2, respectively. In special cases where it may be necessary to cut a tie into several sections, the exact distance from the end to each section should be given.

(4) When a large number of ties are to be analyzed, it will be sufficient to cut but one section two feet from the end, thereby saving the six-foot piece for a narrow-gage tie.

(5) After the sections have been cut, three samples should be taken from each section, as follows: No. 1, one-half inch from outside; No. 3, at the center of the section; No. 2, half-way between No. 1 and No. 3. The samples are taken by boring a hole 2 inches deep with a one-inch bit, saving all the borings. Each sample should be properly labeled, as Tie No. —, Section No. —, Sample No. —, and a list made showing the location, date, number of run, kind of treatment and weight of each tie before and after treatment.

Method of Determining Zinc-Chloride in Samples.

(6) Three grammes of dry borings should be weighed into a 250 cc. flask and three cc. concentrated sulphuric acid added. The flask should be gently heated on a sand bath or hot plate until the wood becomes thoroughly charged. A few drops of concentrated nitric acid should then be added. When the brown fumes have disappeared, a few more drops should be added, and the addition continued, a few drops at a time (toward the last the amount should be increased), until the organic matter is all destroyed. When this point is reached, the liquid will remain colorless on further heating. The flask should then be allowed to cool and diluted with 100 cc. of water (the water should be added carefully at first). As a rule, the residue in the flask will be completely dissolved, but if there should be a slight sediment, it may be disregarded. Ammonium hydroxide should be added until distinctly alkaline, and allowed to cool. If there is a precipitate of iron hydroxide, or if there has been any undissolved sediment in the flask, it should be filtered; if not, it should be poured into a 400 cc. beaker and 5 cc. ammonium sul-

phide added and allowed to stand over night. It should then be filtered into an 11 cm. filter paper, washing thoroughly with water containing ammonium sulphide, and dried. It should then be incinerated in a porcelain crucible and roasted until the zinc-chloride is converted to zinc oxide. The weight should be divided by three and the result multiplied by 1.674, which will give the number of grammes of zinc-chloride contained in one gramme of the wood examined, or the number of pounds per pound. To convert this result into pounds of zinc-chloride per cubic foot of wood, multiply by the weight in pounds of one cubic foot of the wood.

[13] FORMS FOR REPORTING INSPECTION.

Two forms for reporting inspection of treatment are shown. Form "A" provides a record of the treatment and the determination of the absorption of the preservative by gage readings. Form "B" provides a record of the determination of the absorption by weighing.

These forms are intended as general guides for reporting and keeping records of the inspection of the treatment of timbers, and may be varied to suit any special kind of treatment.

The following is explanatory of the gage readings, designated by letter on Form "A":

Reading "A"—Is the reading of the measuring tank gage before the oil is put into the cylinder.

Reading "B"—Is the tank gage reading when the cylinder is completely filled.

Reading "C"—Is the tank gage reading when the pumping of the oil into the cylinder is stopped.

Reading "D"—Is the tank gage reading after all the oil from the charge is returned to the measuring tank.

Reading "A" minus "D," corrected for temperatures, gives the number of gallons used in the charge.

Reading "B" minus "C" gives the number of gallons pumped into the timber after the cylinder is filled and is used to give the gross absorption for high processes where oil is taken out of the timber by an initial air pressure, or by a final vacuum, or both. There will be a discrepancy in this gross absorption, due to the amount of oil absorbed by the timber while cylinder is being filled.

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[13] Adopted, Vol. 14, 1913, pp. 713-716, 1165, 1166.

Form A.

M. W. 1700

____
(Name of Railroad)

________________________________ Department

________________________________ Plant

________________________________ Inspector

Date															
Kind of Treatment															
Retort Number															
Charge Number															
Liquid Used															
Percent of Chloride															
Steam or Air Admitted															
Vacuum Applied															
Liquid Admitted															
Pump Started															
Treatment Ended															
Steam or Air Pressure, Lbs.															
Vacuum, Inches															
Pressure of Liquid, Lbs.															
Measuring Tank Number															
Gallons per Tank Foot															
Reading A.															
Temperature A. Degrees Fahrenheit															
Reading B.															
Temperature B. Degrees Fahrenheit															
Reading C															
Temperature C. Degrees Fahrenheit															
Reading D.															
Temperature D. Degrees Fahrenheit															
Gals. Pumped Into Timber per Charge B. minus C.															
Gallons Pumped Into Timber per Tie															
Pounds Pumped Into Timber per Cu. Ft.															
Total Gallons Used 100° Fahrenheit A. minus D.															
Gals per Cu. Ft. of Timber															
Gallons per Tie															
Lbs. per Cu. Ft. of Timber															
Lbs. of Chloride per Cu. Ft. Timber															
Material Treated.															

Form B.

M. W. 1701

Date ____________

____________________ (Name of Railroad)

Date ____________

Kind of Treatment ____________

____________ Plant

Kind of Treatment ____________

Run No. ____________ Kind of Timber ____________

Kind of Timber ____________ Run No. ____________

Tram Number	No. of Ties	Gross Weight Before Treatment	Weight of Tram	Weight of Ties Before Treatment	Gross Weight After Treatment	Weight of Ties After Treatment	Gain Per Tie	Tram Number	No. of Ties	Gross Weight Before Treatment	Weight of Tram	Weight of Ties Before Treatment	Gross Weight After Treatment	Weight of Ties After Treatment	Gain Per Tie

____________ Inspector

Lbs. of Oil Per Tie ____________ % of Chloride in Solution ____________

Total Gals. Oil @ 100° Fahr. ____________ Total Lbs. Liquid Used ____________

Gals. Absorbed per Tie ____________ Lbs. Chloride per Tie ____________

____________ Inspector

Lbs. of Oil Per Tie ____________ % of Chloride in Solution ____________

Total Gals. Oil @ 100° Fahr. ____________ Total Lbs. Liquid Used ____________

Gals. Absorbed per Tie ____________ Lbs. Chloride per Tie ____________

COMMITTEE XVIII.

ELECTRICITY.

[1]DEFINITIONS.

THIRD RAIL CLEARANCE LINES.—Lines beyond which no part of the third rail structure shall project.

EQUIPMENT CLEARANCE LINES.—Lines beyond which no part of the equipment shall project. Allowance must be made by equipment manufacturer for new equipment for wear on journals and brasses, on axle collars, on rail, on wheels, compression of springs, sagging of center of car, constructional variations, end play, broken springs, etc.

THIRD RAIL GAGE.—Distance measured parallel to plane of top of both running rails betwen gage of nearest running rail and inside gage line of third rail.

BOND.—A metallic means for connecting two rails to permit of passage of electric current.

CABLE.—A rope composed of wires for the transmission of electricity.

ELECTRICAL SUPERVISOR.—An officer on the division staff qualified to supervise the maintenance of the electrical transmission and working conductors outside of the power stations and sub-stations.

BONDERS.—Employés qualified to maintain rail and other bonds and their appurtenances.

TRACTION LINEMEN.—Employés qualified to maintain wires and cables and their appurtenances for all railroad voltages.

PATROLMEN.—Employés qualified to inspect and make minor repairs to track and third-rail structures, cables and wires, and to use hand signals for the protection of trains.

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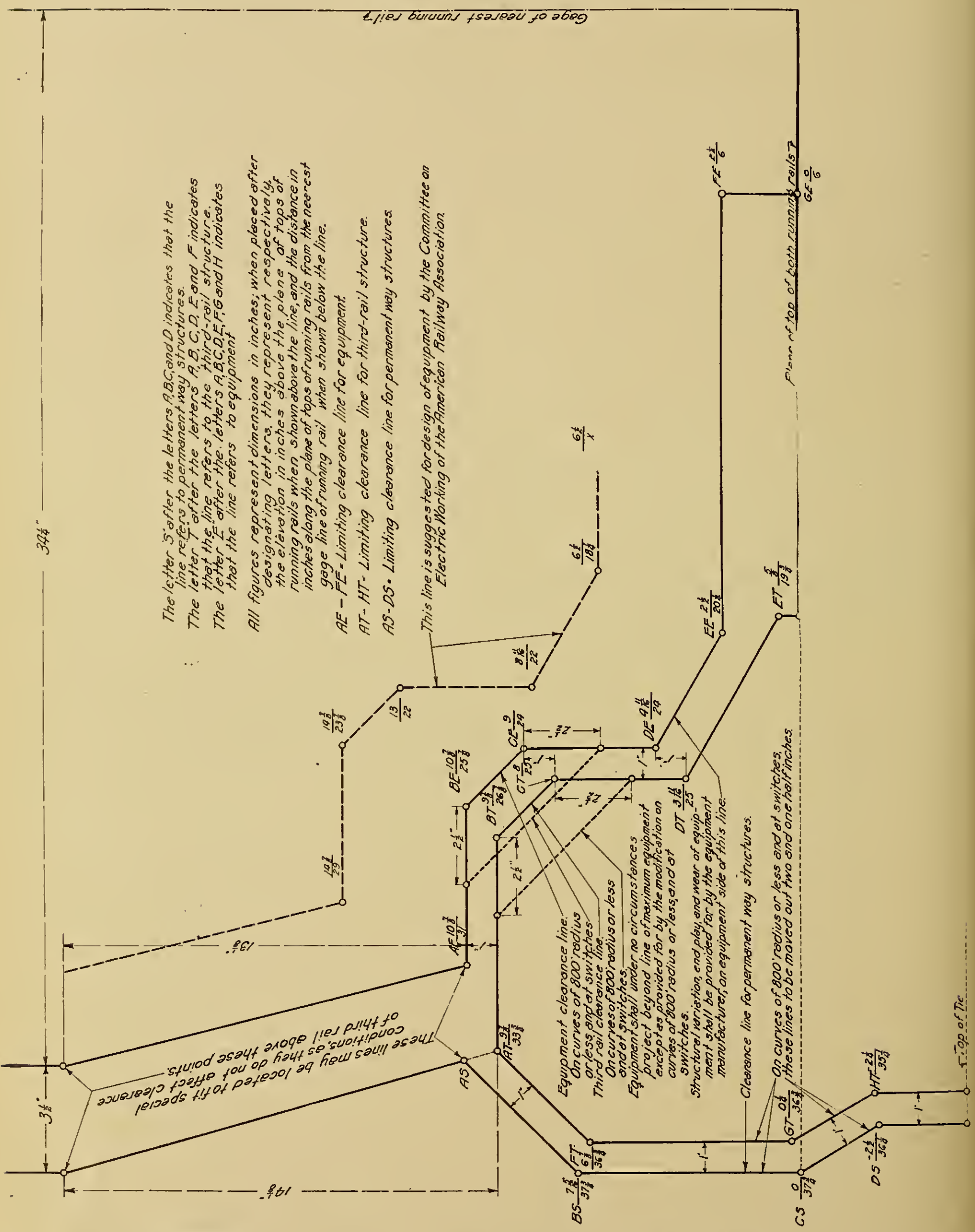
[1] Adopted, Vol. 12, Part 1, 1911, pp. 152, 222; Vol. 13, 1912, pp. 510, 998.

[2]CLEARANCE LINES FOR EQUIPMENT AND PERMANENT WAY STRUCTURES ADJACENT TO THIRD RAIL AND FOR THIRD RAIL STRUCTURE.


The letter "S" after the letters A,B,C and D indicates that the line refers to permanent way structures.
The letter "T" after the letters A, B, C, D, E and F indicates that the line refers to the third-rail structure.
The letter "E" after the letters A,B,C,D,E,F,G and H indicates that the line refers to equipment
All figures represent dimensions in inches; when placed after designating letters, they represent respectively, the elevation in inches above the plane of tops of running rails when shown above the line, and the distance in inches along the plane of tops of running rails from the nearest gage line of running rail when shown below the line.
AE – FE = Limiting clearance line for equipment.
AT - HT = Limiting clearance line for third-rail structure.
AS - DS = Limiting clearance line for permanent way structures.
This line is suggested for design of equipment by the Committee on Electric Working of the American Railway Association.
These lines may be located to fit special conditions, as they do not affect clearance of third rail above these points.
Equipment clearance line.
On curves of 800' radius or less and at switches
Third rail clearance line.
On curves of 800' radius or less and at switches.
Equipment shall under no circumstances project beyond line of maximum equipment except as provided for by the modification on curves of 800' radius or less, and at switches.
Structural variation, end play, and wear of equipment shall be provided for by the equipment manufacturer, on equipment side of this line.
Clearance line for permanent way structures.
On curves of 800' radius or less and at switches, these lines to be moved out two and one half inches.
Gage of nearest running rail
Plane of top of both running rails
Top of Tie
34¼"
3½"
14⅛"
13⅜"
2½"
1"
14⅞ / 29
19⅞ / 23⅞
13 / 22
8 11/16 / 22
6½ / 18¼
6½ / x
AS
AE 10⅞ / 31
BE 10⅞ / 25⅞
AT 9⅞ / 33⅜
BT 9⅞ / 26⅜
CE 9 / 29
CT 8 / 25¼
DE 4 11/16 / 29
DT 3 11/16 / 25
EE 2½ / 20⅜
ET ⅝ / 19¾
FE 2½ / 6
GE 0 / 6
BS 7 5/16 / 37¾
FT 6⅞ / 36⅜
CS 0 / 37¾
GT 0⅝ / 36⅜
DS -2½ / 36⅛
HT -2⅝ / 35⅛

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[2] Adopted, Vol. 13, 1912, pp. 511, 525, 998; Vol. 16, 1915, pp. 927, 1187.

[3]OVERHEAD CLEARANCE LINES FOR PERMANENT WAY STRUCTURES ON ELECTRIFIED RAILROADS.

Momentary obstruction, such as signal blades, may approach pantagraph clearance line.

Sway of pantagraph based on 1 inch difference in height of car springs; ½ inch difference in elevation of track rail, and sway of 6 inches either side at 22 feet above top of rail for pantagraph itself.

These diagrams show minimum clearance; additional clearances will be required to provide for special features of design, sag between points of support as affected by length of span and temperature changes, and also for steady strains, pull-offs, etc., if any.

All heights to be measured at right angles to plane of rails at center line of track.

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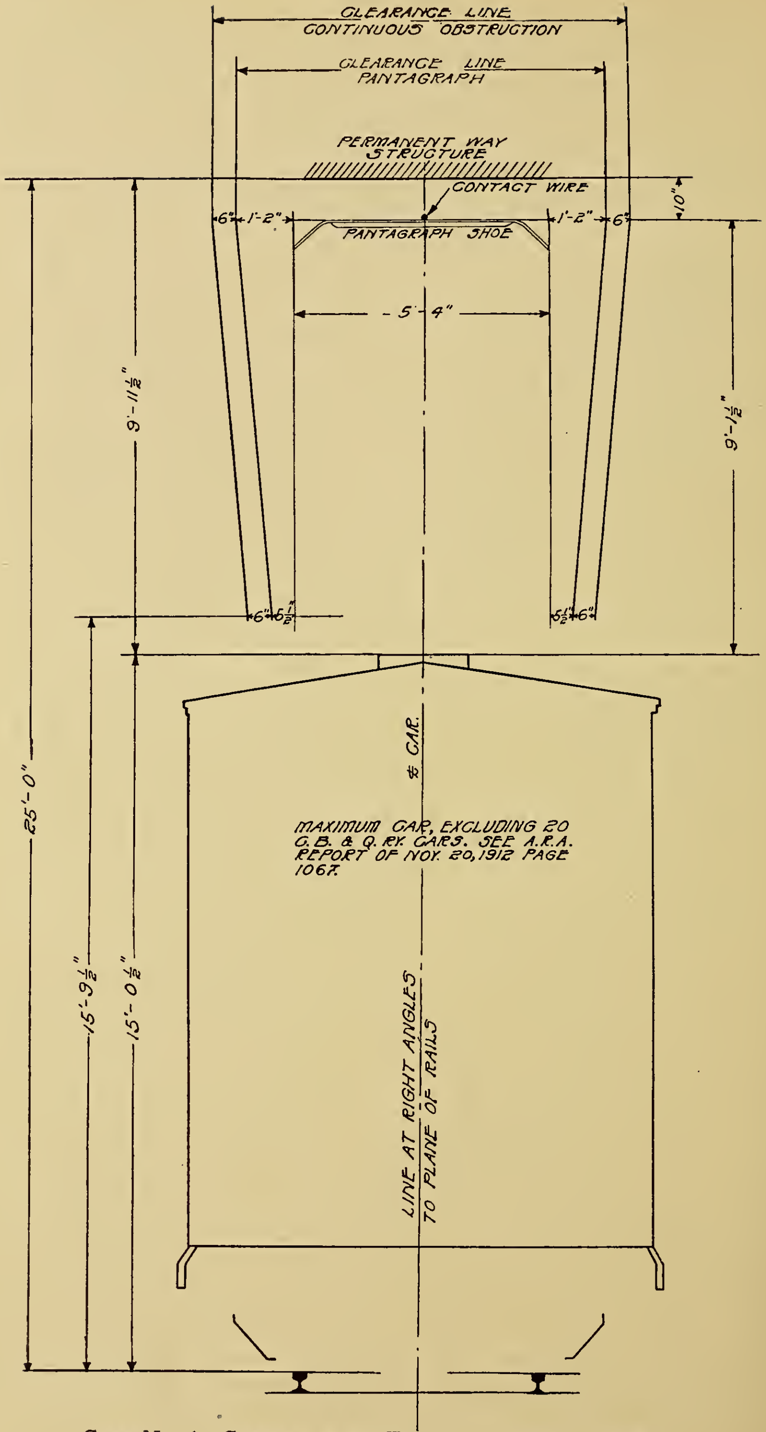
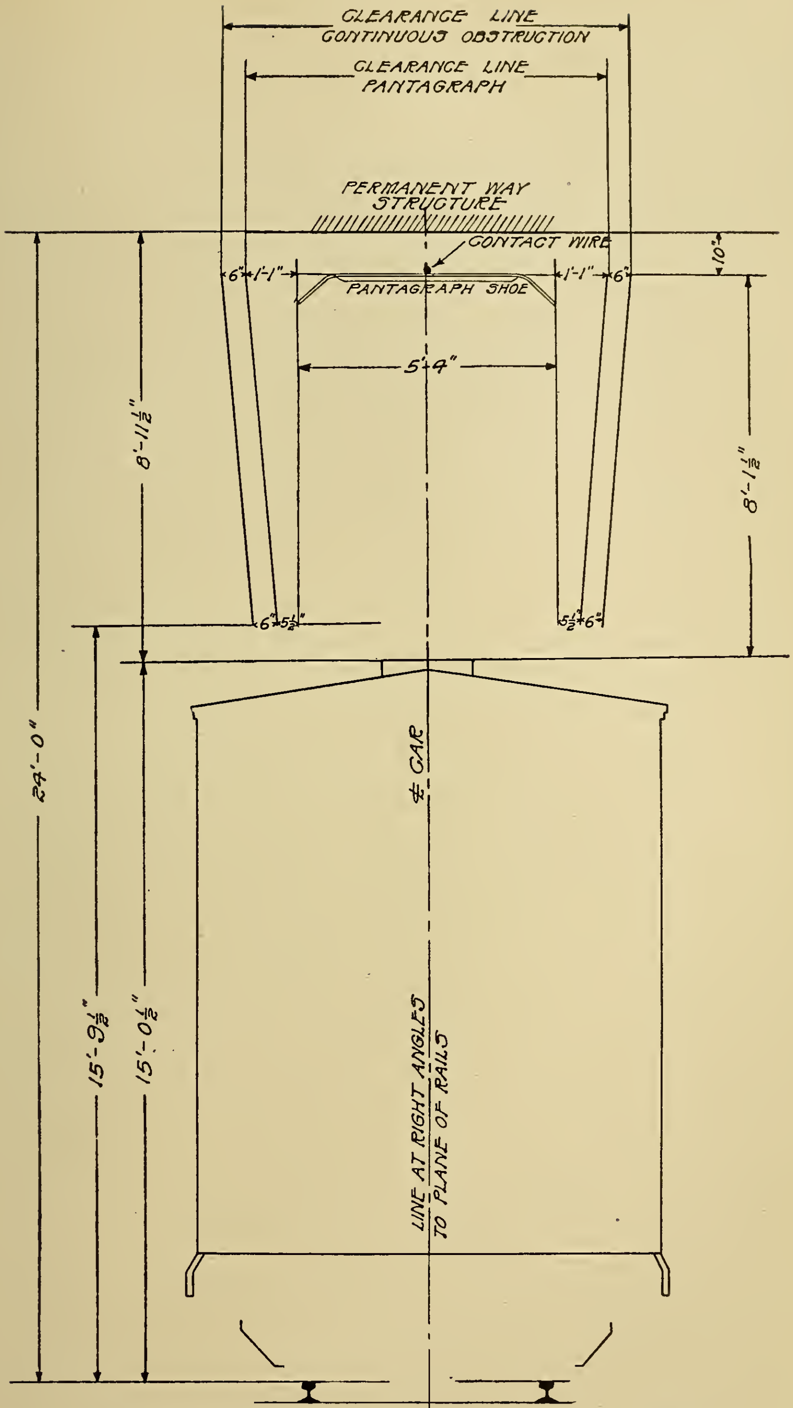
[3] Adopted, Vol. 15, 1914, pp. 618-624, 1071.



Case No. 1—Clearance for Trainman With Lantern.

ASSUMPTIONS.

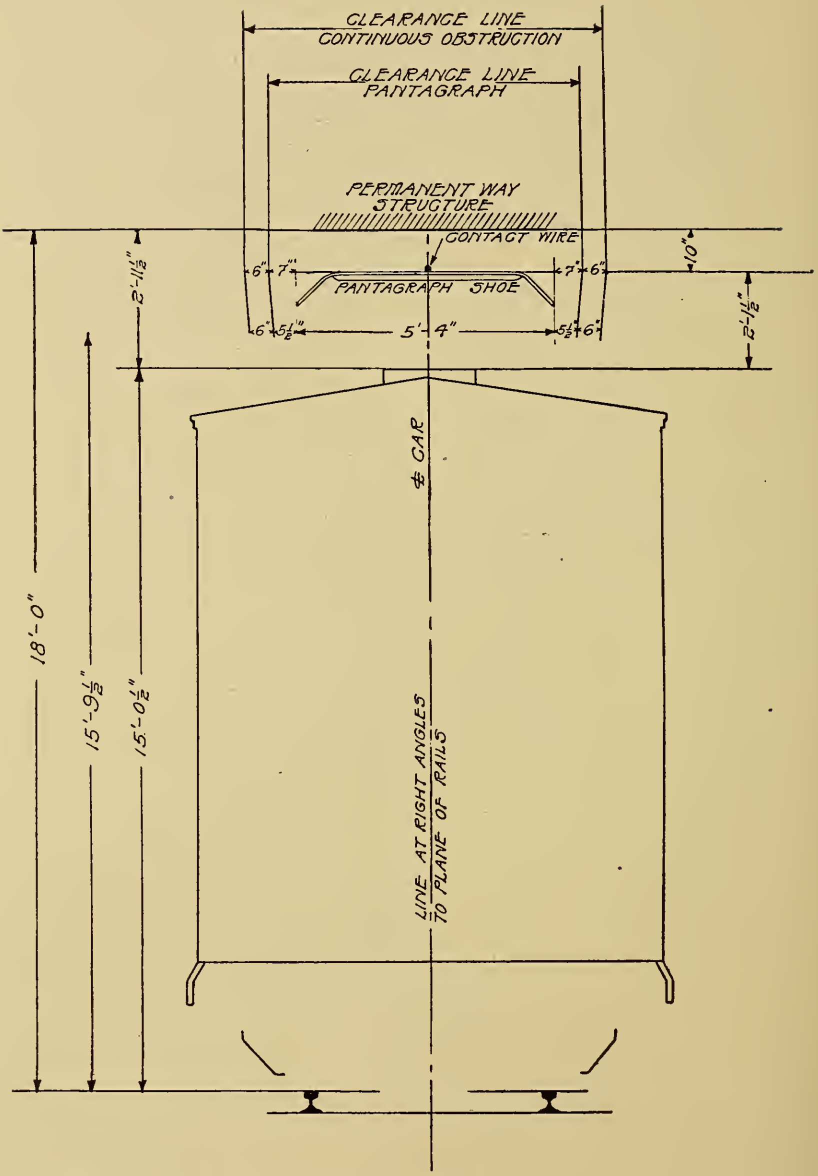
Reach of 6-foot trainman	7 feet 8 inches
Lantern swing	1 foot 0 inches
Clearance	0 feet 5½ inches
Total distance car running board to wire	9 feet 1½ inches



Case No. 2—Clearance for Trainman Without Lantern.

ASSUMPTIONS.

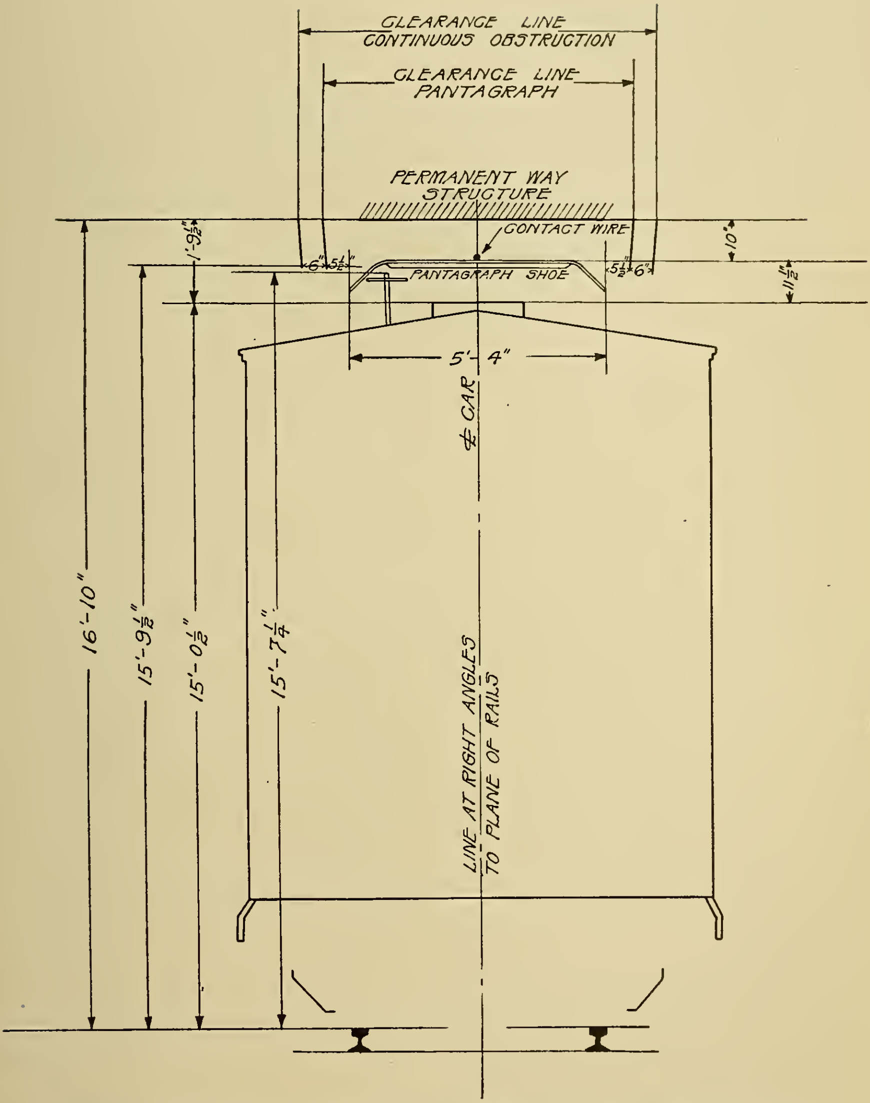
Reach of 6-foot trainman	7 feet 8 inches
Clearance	0 feet 5½ inches
Total distance car running board to wire	8 feet 1½ inches



Case No. 3—Normal Minimum Clearance Without Trainman on Cars.

ASSUMPTION.

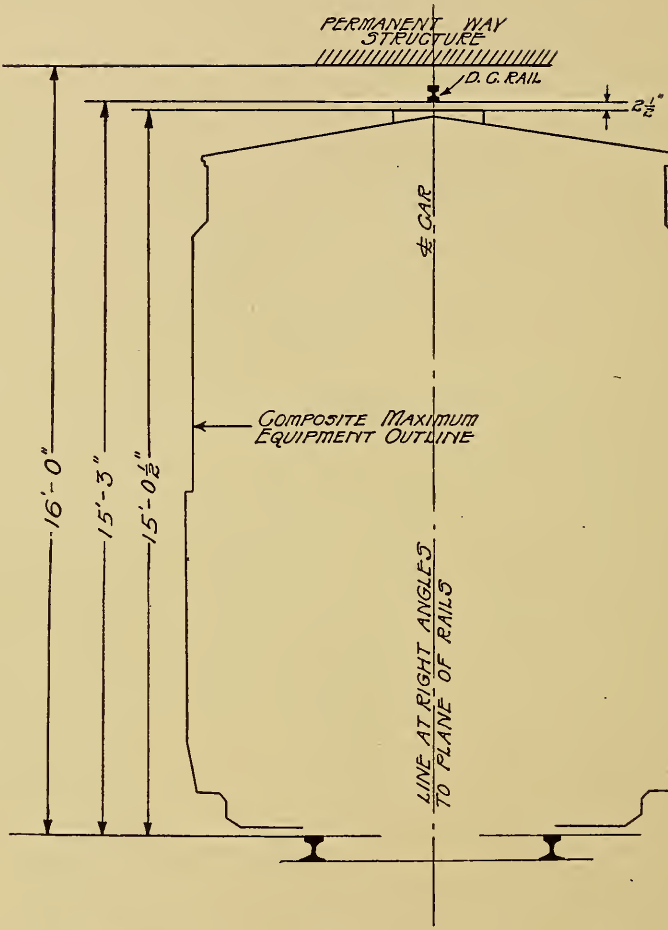
Normal distance car running board to wire............2 feet 1½ inches



Case No. 4—Special Minimum Clearance Without Trainman on Cars.

ASSUMPTION.

Minimum distance car running board to wire..........0 feet 11½ inches


PERMANENT WAY STRUCTURE
D. C. RAIL
2½"
℄ CAR
COMPOSITE MAXIMUM EQUIPMENT OUTLINE
16'-0"
15'-3"
15'-0½"
LINE AT RIGHT ANGLES TO PLANE OF RAILS

Case No. 5—Minimum Clearance D. C. Overhead.

ASSUMPTION.

Minimum distance car running board to rail...........0 feet 2½ inches

[4]SPECIFICATIONS FOR OVERHEAD CROSSINGS OF ELECTRIC LIGHT AND POWER LINES.

GENERAL REQUIREMENTS.

Scope.

1. This specification shall apply to Overhead Electric Light and Power Line Crossings (except trolley contact wires), over railroad right-of-way, tracks, or lines of wires; and, further, these specifications shall apply to Overhead Electric Light and Power Wires of over 5000 volts constant potential, crossing telephone, telegraph or other similar lines. It is not intended that these specifications shall apply to crossings over individual twisted pair drop wires, or other circuits of minor importance where equally effective protection may be secured more economically by other methods of construction.

Location.

2. Poles, or towers, supporting the crossing span preferably shall be outside the railroad company's right-of-way.

3. Unusually long crossing spans shall be avoided wherever practicable, and the difference in length of the crossing and adjoining spans generally shall be not more than 50 per cent. of the length of the crossing span.

4. Poles, or towers, shall be located as far as practicable from inflammable material or structures.

5. Poles, or towers, supporting the crossing span, and the adjoining span on each side, preferably shall be in a straight line.

6. Wires, or cables, shall cross over telegraph, telephone, and similar wires wherever practicable.

7. Cradles, or overhead bridges, shall not be used beneath the crossing wires or cables; but in cases where the crossing wires or cables cross beneath the railroad wires, telephone, telegraph, or other similar wires, a protection of adequate strength and proper design between the two sets of crossing wires or cables may be required.

8. Unless physical conditions or municipal requirements prevent, the side clearance shall be not less than 12 feet from the nearest track rail, except that at sidings a clearance of not less than 7 feet may be allowed. At loading sidings sufficient space shall be left for a driveway.

9. The clear headroom shall be not less than 30 feet above the top

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[4] Adopted, Vol. 13, 1912, pp. 512, 1000; Vol. 16, 1915, pp. 948, 1187.

of rail under the most unfavorable condition of temperature and loading. For constant potential, direct-current circuits, not exceeding 750 volts, when paralleled by trolley contact wires, the clear headroom need not exceed 25 feet

10. The clearance of alternating-current circuits above any existing wires, under the most unfavorable condition of temperature and loading, shall be not less than 8 feet wherever possible. For constant potential, direct-current circuits, not exceeding 750 volts, the minimum clearance above telegraph, telephone, and similar wires may be 2 feet with insulated wires and 4 feet with bare wires.

11. The separation of conductors carrying alternating current, supported by pin insulators, for spans not exceeding 150 feet, shall be not less than:

Line Voltage.	Separation.
Not exceeding 7,000 volts	12 inches
Exceeding 7,000, but not exceeding 14,000	20 inches
Exceeding 14,000, but not exceeding 27,000	30 inches
Exceeding 27,000, but not exceeding 35,000	36 inches
Exceeding 35,000, but not exceeding 47,000	45 inches
Exceeding 47,000, but not exceeding 70,000	60 inches

For spans exceeding 150 feet the pin spacing should be increased, depending upon the length of the span and the sag of the conductors.*

With constant potential, direct-current circuits not exceeding 750 volts, the minimum spacing shall be 10 inches.

12. When supported by insulators of the disc or suspension type, the crossing span and the next adjoining spans shall be dead-ended at the poles, or towers, supporting the crossing span, so that at these poles, or towers, the insulators shall be used as strain insulators, or the height of the wire attachments shall be such that with the maximum sag in the crossing span occurring from failure of the construction outside the crossing span, and taking into account the deflections in the strings of suspension insulators, the minimum clearances, as given in paragraphs 9 and 10, shall be maintained.

13. The clearance in any direction between the conductors nearest the pole, or tower, and the pole, or tower, shall be not less than:

Line Voltage.	Clearances.
Not exceeding 10,000 volts	9 inches
Exceeding 10,000, but not exceeding 14,000	12 inches
Exceeding 14,000, but not exceeding 27,000	15 inches
Exceeding 27,000, but not exceeding 35,000	18 inches
Exceeding 35,000, but not exceeding 47,000	21 inches
Exceeding 47,000, but not exceeding 70,000	24 inches

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*Note.—This requirement does not apply to wires of the same phase or polarity between which there is no difference of potential.

Conductors.

14. The normal mechanical tension in the conductors generally shall be the same in the crossing span and in the adjoining span on each side.

15. Conductors shall not be spliced in the crossing span nor in the adjoining span on either side.

Taps to conductors in the crossing span are generally objectionable, and should not be made unless necessary.

16. Ties or devices for supporting the conductors at the poles, or towers, shall be such as to hold the wires, under maximum loading, to the supporting structures, in case of shattered insulators, or wires broken or burned at an insulator, without allowing an amount of slip, which would materially reduce the clearance specified in paragraphs 9 and 10.

Ground Wires.

17. When installed as protection against lightning, shall be thoroughly grounded at each of the crossing supports. In case of their installation on steel supporting structures, they may be clamped thereto. In case they are installed on wooden structures, the ground wire shall be grounded at each of the structures with a solid copper wire, with as few bends as possible, and no sharp bends, and not less than No. 4 B. & S. gage or equivalent copper section. The ground wire itself, in the crossing span and the adjacent spans, may be of the same material as the conductors, or a steel strand not less than $\frac{5}{16}$ inch in diameter may be used, double galvanized, and having a breaking strength of not less than 4500 lbs. and in general shall follow the minimum factors of safety, as provided for the rest of the crossing construction.

If cross-arms are grounded, the same ground wire may be used for grounding the lightning protection wire as in grounding cross-arm strips.

18. Where there is an upward stress at the point of conductor attachment, the attachment shall be of such type as to properly hold the conductor in place.

Guys.

19. Wooden poles supporting the crossing span shall be side-guyed in both directions, if practicable, and be head-guyed away from the crossing span, and the next adjoining poles shall be head-guyed toward the crossing span. Braces may be used instead of guys.

Strain Insulators.

20. Strain insulators shall be used in guys from wooden poles, except when the guys are through grounded to permanently damp earth.

The insulators shall be placed not less than 8 feet from the ground. Strain insulators shall not be used in guying steel poles or structures.

Clearing.

21. The space around the poles, or towers, shall be kept free from inflammable material, underbrush and grass.

Signs.

22. In the case of railroad crossings, if required by the railroad company, warning signs of an approved design shall be placed on all poles and towers located on the railroad company's right-of-way.

Grounding.

23. For voltages over 5000 volts, wooden cross-arms, if used, shall be provided with a grounded metallic plate on top of the arm, which shall be not less than ⅛ inch in thickness, and which shall have a sectional area and conductivity not less than that of the line conductor. Metal pins shall be electrically connected to this ground. Metal poles and metal arms on wooden poles shall be grounded.

24. The electrical conductivity of the ground conductor shall be adjusted to the short-circuit current capacity of the system at the crossing, and shall be not less than that of a No. 4 B. & S. gage copper wire.

Temperature.

25. In the computation of stresses and clearances, and in erection, provision shall be made for a variation in temperature from —20 degrees Fahrenheit to + 120 degrees Fahrenheit. A suitable modification in the temperature requirements shall be made for regions in which the above limits would not fairly represent the extreme range of temperature.

Inspection.

26. If required by contract, all material and workmanship shall be subject to the inspection of the company crossed; provided, that reasonable notice of the intention to make shop inspection shall be given by such company. Defective material shall be rejected and shall be removed and replaced with suitable material.

27. On the completion of the work, all falsework, plant and rubbish incident to the construction shall be removed promptly and the site left unobstructed and clean.

Drawings.

28. If required, by contract, ...(......) complete sets of general and detail drawings shall be furnished for approval before any construction is commenced.

LOADS.

29. Conductors shall be considered as uniformly loaded throughout their length, with a load equal to the resultant of the dead load plus the weight of a layer of ice ½ inch in thickness and a wind pressure of 8 lbs. per square foot on the ice-covered diameter, at a temperature of 0 degrees Fahrenheit.

30. The weight of ice shall be assumed as 57 lbs. per cubic foot (0.033 lbs. per cubic inch).

31. Insulators, pins and conductor attachments shall be designed to withstand the mechanical tension in the conductors under the maximum loadings with the designated factor of safety.

32. Sags should be such that the stress on the pin falls within the limits of paragraph 31, unless methods be employed to prevent an undue slip in case of pin failure. (See paragraphs 9, 10 and 16.)

33. Poles, or towers, shall be designed to withstand, with the designated factor of safety, the combined stresses from their own weight, the wind pressure on the pole, or tower, and the above wire loading on the crossing span and the next adjoining span on each side. The wind pressure on the poles, or towers, shall be assumed at 13 lbs. per square foot on the projected area of solid or closed structures and 1½ times the projected area of latticed structures.

34. Poles, or towers, shall also be designed to withstand the loads specified in paragraph 33, combined with the unbalanced tension of:

2 broken wires for poles, or towers, carrying 5 wires or less.
3 broken wires for poles, or towers, carrying 6 to 10 wires.
4 broken wires for poles, or towers, carrying 11 or more wires.

35. Cross-arms shall be designed to withstand the loading specified in paragraph 33, combined with the unbalanced tension of one wire broken at the pin farthest from the pole.

36. Poles, or towers, may be permitted a reasonable deflection under the specified loading, provided that such deflection does not reduce the clearance specified in paragraph 10 more than 25 per cent., or produce stresses in excess of those specified in paragraph 69 to 73,

FACTORS OF SAFETY.

37. The ultimate unit stress divided by the allowable unit stress shall be not les than the following:

Wires and cables	2
Pins	2
Insulators, conductor attachments, guys	3
Wooden poles and cross-arms	6
Structural steel	3
Reinforced concrete poles and cross-arms	4
Foundations	2

Insulators.

38. Insulators for line voltages of less than 9000 shall not flash over at four times the normal working voltage, under a precipitation of water ⅕-inch per minute, at an inclination of 45 degrees to the axis of the insulator.

39. Each separate part of a built-up insulator, for line voltages over 9000, shall be subjected to the dry flash-over test of that part for 5 consecutive minutes.

40. Each assembled and cemented insulator shall be subjected to its dry flash-over test for 5 consecutive minutes.

The dry flash-over test shall be not less than:

Line Voltage.	Test Voltage.
Exceeding 9,000, but not exceeding 14,000	65,000
Exceeding 14,000, but not exceeding 27,000	100,000
Exceeding 27,000, but not exceeding 35,000	125,000
Exceeding 35,000, but not exceeding 47,000	150,000
Exceeding 47,000, but not exceeding 60,000	180,000
Exceeding 60,000	three times line voltage

Each insulator shall further be so designed that, with excessive potential, failure will first occur by flash-over and not by puncture.

41. Each assembled insulator shall be subjected to a wet flash-over test, under a precipitation of water of ⅕-inch per minute, at an inclination of 45 degrees to the axis of the insulator.

The wet flash-over test shall be not less than:

Line Voltage.	Test Voltage.
Exceeding 9,000, but not exceeding 14,000	40,000
Exceeding 14,000, but not exceeding 27,000	60,000
Exceeding 27,000, but not exceeding 35,000	80,000
Exceeding 35,000, but not exceeding 47,000	100,000
Exceeding 47,000, but not exceeding 60,000	120,000
Exceeding 60,000	twice the line voltage

Note.—The use of treated wooden poles and cross-arms is recommended. The treatment of wooden poles and cross-arms should be by thorough impregnation with preservative by either closed or open tank process. For poles, except in the case of yellow pine, the treatment need not extend higher than a point two feet above the ground line.

42. Test voltages above 35,000 volts shall be determined by the American Institute Electrical Engineers Standard Spark-Gap Method.

43. Test voltages below 35,000 volts shall be determined by transformer ratio.

MATERIAL.

Conductors.

44. The conductors shall be of copper, aluminum, or other noncorrodible material, except that in exceptionally long spans, where the required mechanical strength cannot be obtained with the above materials, galvanized or copper-covered steel strand may be used.

45. For voltages not exceeding 750 volts, solid or stranded conductors may be used up to and including 0000 in size; above 0000 in size, stranded conductors shall be used. For voltages exceeding 750 volts, and not exceeding 5000 volts, solid or stranded conductors may be used up to and including 00 in size; above 00 in size, conductors shall be stranded. For voltages exceeding 5000 volts, all conductors shall be stranded. Aluminum conductors for all voltages and sizes shall be stranded.

The minimum size of conductors shall be as follows:

No. 6 B. & S. gage copper for voltages not exceeding 5000 volts.
No. 4 B. & S. gage copper for voltages exceeding 5000 volts.
No. 1 B. & S. gage aluminum for all voltages.

Insulators.

46. Insulators shall be of porcelain for voltage exceeding 5000 volts.

47. For pin type insulators, there shall be a bearing contact between the pin and the insulator pin hole up to the level of the top of the tie wire groove, the purpose being that the pin should directly take the strain imposed upon the insulator.

48. Strain insulators for guys shall have an ultimate strength of not less than twice that of the guy in which placed. Strain insulators shall be so constructed that the guy wires holding the insulator in position will interlock in case of the failure of the insulator.

For less than 5000 volts, strain insulators for guys shall not flash over at four times the maximum line voltage under a precipitation of water of ⅕-inch per minute, at an inclination of 45 degrees to the axis of the insulator. For voltages of more than 5000 volts, the strain insulator or series of strain insulators shall not fail at the line voltage under the above precipitation conditions.

Pins.

49. For voltages of 5000 and over, insulator pins shall be of steel, wrought iron, malleable iron, or other approved metal or alloy, and shall

be galvanized, or otherwise protected from corrosion. (See paragraph 47.)

Guys.

50. Guys shall be galvanized or copper-covered stranded steel cable not less than $\frac{5}{16}$-inch in diameter, or galvanized rolled rods, neither to have an ultimate tensile strength of less than 4500 lbs.

51. Guys to the ground shall connect to a galvanized anchor rod, extending at least one foot above the ground level.

52. The detail of the anchorage shall be definitely shown upon the plans.

Wooden Poles.

53. Wooden poles shall be of selected timber, reasonably straight, peeled, free from defects which would decrease their strength or durability, not less than 8 inches in diameter at the top, and meeting the requirements as specified in paragraphs 19, 33, 34 and 37.

Concrete.

54. Concrete and concrete material shall be in accordance with the requirements of the report* of the Joint Committee on Concrete and Reinforced Concrete.

STRUCTURAL STEEL.

55. Structural steel shall be in accordance with the Manufacturers' Standard Specifications.

56. The design and workmanship shall be strictly in accordance with first-class practice.

57. The form of the frame shall be such that the stresses may be computed with reasonable accuracy, or the strength shall be determined by actual test.

58. The sections used shall permit inspection, cleaning and painting, and shall be free from pockets in which water or dirt can collect.

59. The length of a main compression member shall not exceed 180 times its least radius of gyration. The length of a secondary compression member shall not exceed 220 times its least radius of gyration.

60. The minimum thickness of metal in galvanized structures shall be ¼-inch for main members and ⅛-inch for secondary members. The minimum thickness of painted material shall be ¼-inch.

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*This may be found in the February, 1913, Proceedings of the American Society of Civil Engineers, Vol. 59, No. 2, pp. 117-168.

PROTECTIVE COATINGS.

61. Structural steel shall be thoroughly cleaned at the shop and be galvanized, or given one coat of approved paint.

Painted Materials.

62. Contact surfaces shall be given one coat of paint before assembling.

Painted structural steel shall be given two field coats of an approved paint.

The surface of the metal shall be thoroughly cleaned of all dirt, grease, scale, etc., before painting, and no painting shall be done in freezing or rainy weather.

Galvanized Material.

63. Galvanized material shall be in accordance with the Specification for Galvanizing Iron and Steel.

Bolt holes in galvanized material shall be made before galvanizing. Sherardizing for small parts is permissible.

FOUNDATIONS.

64. The foundations for steel poles and towers shall be designed to prevent overturning.

The weight of concrete shall be assumed as 140 lbs. per cubic foot. In good ground, the weight of "earth" (calculated at 30 degrees from the vertical) shall be assumed as 100 lbs. per cubic foot. In swampy ground, special measures shall be taken to prevent uplift or depression.

Concrete for foundation shall be well worked, very wet, and shall not be leaner than one part Portland cement, three parts clean, sharp sand, and six parts of broken stone, or one part Portland cement to six parts of good gravel, free from loam or clay.

65. The top of the concrete foundation, or casing, shall be not less than 6 inches above the surface of the ground, nor less than 1 foot above high water, except that no foundation need be higher than the base of the railroad company's rail, or the top of the traveled roadway.

66. When located in swampy ground, wooden crossing and next adjoining poles shall be set in barrels of broken stone or gravel, or in broken stone or timber footings.

67. When located in the sides of banks, or when subject to washouts, foundations shall be given additional depth, or be protected by cribbing or riprap.

68. Foundations and pole settings shall be tamped in 6-inch layers, while back filling. It is desirable in back filling that the earth be suitably moistened.

WORKING UNIT STRESSES.

Obtained by dividing the ultimate breaking strength by the factors of safety given in paragraph 37.

69. **Structural Steel.**

	Lbs. Per Sq. In.
Tension (net section)	18,000
Shear	14,000
Compression	$18{,}000 - 60\frac{l}{r}$

70. **Rivets, Pins.**

Shear	10,000
Bearing	20,000
Bending	20,000

71. **Bolts.**

Shear	8,500
Bearing	17,000
Bending	17,000

72. **Wires and Cables.**

	Lbs. Per Sq. In.
Copper, hard-drawn, solid, B. & S. gage 0000, 000, 00	25,000
Copper, hard-drawn, solid, B. & S. gage 0	27,500
Copper, hard-drawn, solid, B. & S. gage No. 1	28,500
Copper, hard-drawn, solid, B. & S. gage No. 2, 4, 6	30,000
Copper, soft-drawn, solid	17,000
Copper, hard-drawn, stranded	30,000
Copper, soft-drawn, stranded	17,000
Aluminum, hard-drawn, stranded, B. & S. gage under 0000	12,000
Aluminum, hard-drawn, stranded, B. & S. gage 0000 and over	11,500

73. **Untreated Timber.**

	Lbs. Per Sq. In.		
Eastern white cedar	600	600	$(1-\frac{L}{60D})$
Chestnut	850	850	"
Washington cedar	850	850	"
Idaho cedar	850	850	"
Port Orford cedar	1,150	1,150	"
Longleaf yellow pine	1,000	1,000	"
Shortleaf yellow pine	800	800	"
Douglas fir	900	900	"
White oak	950	950	"
Red cedar	700	700	"
Bald cypress (heartwood)	800	800	"
Redwood	650	650	"
Catalpa	500	500	"
Juniper	550	550	"

L = Length in inches.
D = Least side, or diameter, in inches.

[5]SPECIFICATIONS FOR GALVANIZING ON IRON OR STEEL.

This specification gives in detail the test to be applied to galvanized material. All specimens shall be capable of withstanding these tests.

Coating.

(a) The galvanizing shall consist of a continuous coating of pure zinc of uniform thickness, and so applied that it adheres firmly to the surface of the iron or steel. The finished product shall be smooth.

Cleaning.

(b) The samples shall be cleaned before testing, first with carbona, benzine or turpentine, and cotton waste (not with a brush), and then thoroughly rinsed in clean water and wiped dry with clean cotton waste.

The sample shall be clean and dry before each immersion in the solution.

Solution.

(c) The standard solution of copper sulphate shall consist of commercial copper sulphate crystals dissolved in cold water, about in the proportion of 36 parts, by weight, of crystals to 100 parts, by weight, of water. The solution shall be neutralized by the addition of an excess of chemically pure cupric oxide (CuO). The presence of an excess of cupric oxide will be shown by the sediment of this reagent at the bottom of the containing vessel.

The neutralized solution shall be filtered before using by passing through filter paper. The filtered solution shall have a specific gravity of 1.186 at 65 degrees Fahrenheit (reading the scale at the level of the solution) at the beginning of each test. In case the filtered solution is high in specific gravity, clean water shall be added to reduce the specific gravity to 1.186 at 65 degrees Fahrenheit. In case the filtered solution is low in specific gravity, filtered solution of a higher specific gravity shall be added to make the specific gravity 1.186 at 65 degrees Fahrenheit.

As soon as the stronger solution is taken from the vessel containing the unfiltered neutralized stock solution, additional crystals and water must be added to the stock solution. An excess of cupric oxide shall always be kept in the unfiltered stock solution.

Quantity of Solution.

(d) Wire samples shall be tested in a glass jar of at least 2 inches inside diameter. The jar without the wire samples shall be filled with standard solution to a depth of at least 4 inches. Hardware samples shall be tested in a glass or earthenware jar containing at least ½ pint of standard solution for each hardware sample. Solution shall not be used for more than one series of four immersions.

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[5] Adopted, Vol. 13, 1912, pp. 519, 1015; Vol. 16, 1915, pp. 946, 1188.

Samples.

(e) Not more than seven wires shall be simultaneously immersed, and not more than one sample of galvanized material other than wire shall be immersed in the specified quantity of solution.

The samples shall not be grouped or twisted together, but shall be well separated so as to permit the action of the solution to be uniform upon all immersed portions of the samples.

Test.

(f) Clean and dry samples shall be immersed in the required quantity of standard solution in accordance with the following cycle of immersions.

The temperature of the solution shall be maintained between 62 and 68 degrees Fahrenheit at all times during the following test:

(1) Immerse for one minute, wash and wipe dry.
(2) Immerse for one minute, wash and wipe dry.
(3) Immerse for one minute, wash and wipe dry.
(4) Immerse for one minute, wash and wipe dry.

After each immersion the samples shall be immediately washed in clean water having a temperature between 62 and 68 degrees Fahrenheit, and wiped dry with cotton waste.

In the case of No. 14 galvanized iron or steel wire, the time of the fourth immersion shall be reduced to one-half minute.

Rejection.

(g) If, after the test described in section f, there should be a bright metallic copper deposit upon the samples, the lot represented by the samples shall be rejected.

Copper deposits on zinc or within one inch of the cut end shall not be considered causes for rejection.

In the case of a failure of only one wire in a group of seven wires immersed together, or if there is a reasonable doubt as to the copper deposit, two check tests shall be made on these seven wires and the lot reported in accordance with the majority of the sets of tests.

NOTE.

The equipment necessary for the tests herein outlined is as follows:

Filter paper.
Commercial copper sulphate crystals.
Chemically pure cupric oxide (CuO).
Running water.
Warm water of ice as per needs.
Carbona, benzine or turpentine.
Glass jars at least two inches inside diameter by at least four and one-half inches high.
Glass or earthenware jars for hardware samples.
Vessel for washing samples.
Tray for holding jars of stock solution.
Jars, bottles and porcelain basket for stock solution.
Cotton waste.
Hydrometer cylinder 3 inches diameter bv 15 inches high.
Thermometer with large Fahrenheit scale correct at 62 and 68 degrees.
Hydrometer correct at 1.186 at 65 degrees Fahrenheit.

[6]SPECIFICATIONS FOR CROSSINGS OF WIRES OR CABLES OF TELEGRAPH, TELEPHONE, SIGNAL AND OTHER CIRCUITS OF SIMILAR CHARACTER OVER STEAM RAILROAD RIGHTS-OF-WAY, TRACKS OR LINES OF WIRES OF THE SAME CLASSES.

1. Scope.

These specifications cover the construction and maintenance of lines of aerial wires or cables of telegraph, telephone, signal, and all other electric wires of similar character crossing steam railroad rights-of-way, tracks, or lines of wires of the classes mentioned above. They prescribe the standard practice to be followed. In matters not specifically prescribed, or when local conditions make the prescribed practice impracticable, they shall be met by methods that will provide equivalent security and protection of life and property.

Wires covered by these specifications shall not carry more than 550 volts.

2. Drawings.

Complete drawings shall be furnished in duplicate before construction is commenced. These drawings shall show the general plan of the right-of-way, tracks, and wires to be crossed and the construction proposed, including the locations of the poles supporting the crossing span and the adjoining spans on either side of the crossing span, the number, kind and size of wires, and the proposed clearances of the existing tracks and wires.

3. Location of Poles.

(a) Spans crossing railroad rights-of-way preferably should be supported upon poles placed outside of the right-of-way; but spans over tracks, and one span adjoining them on each side, should not exceed 125 feet in length. When impracticable to obtain a span of 125 feet the length of the crossing span shall be as short as practicable, but shall not exceed 175 feet, and the material, size and sag of conductors shall meet the requirements hereinafter specified. When the span length exceeds 125 feet the spans adjoining the crossing span should not exceed 110 feet.

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[6] Adopted, Vol. 16, 1915, pp. 939, 1187.

(b) Wherever practicable, the poles supporting the crossing span and the adjoining span on each side thereof shall be in a straight line, and the angle between the crossing line and the railroad tracks or pole line shall not be less than 45 degrees.

(c) The poles shall be located as far as practicable from inflammable materials or structures.

(d) Unless physical conditions or municipal requirements prevent, the side clearance shall be not less than 12 feet from the nearest track rail, except that at sidings a clearance of not less than 7 feet may be allowed. At loading sidings sufficient space shall be left for a driveway.

4. Position and Clearance of Wires and Cables.

(a) Wires and cables shall give a clearance of not less than 25 feet above the rail, under the most unfavorable conditions of temperature and loading.

(b) The clearance of wires and cables from any existing wire shall not be less than 2 feet, under the most unfavorable conditions of temperature and loading.

5. Poles.

Wooden poles shall be of one piece of selected timber, peeled, reasonably straight, and free from defects, which would decrease their strength or durability. Poles of various kinds of timber shall have the following dimensions at the top and 6 feet from the butt:

EASTERN WHITE CEDAR:	Length of Poles, Feet.	Not Over 12 Wires, Inches.	Not Over 20 Wires, Inches.	Not Over 40 Wires, Inches.	Not Over 80 Wires, Inches.
Minimum Top Circumference..	..	17¼	18¾	22	24
Minimum Circumference 6 feet from Butt	20	25½	27	..	..
	22	27	28½	30	..
	25	28	30	32	36
	30	31	33	36	40
	35	34	36	38	43
	40	37	40	43	47
	45	40	43	47	50
	50	42	46	50	53
	55	45	49	53	56
	60	..	52	56	59

Western Cedar:

	Length of Poles, Feet.	Not Over 12 Wires, Inches.	Not Over 20 Wires, Inches.	Not Over 40 Wires, Inches.	Not Over 80 Wires, Inches.
Minimum Top Circumference.. ..		18½	22	25	28
Minimum Circumference 6 feet from Butt	20	24	26	..	..
	22	25	27	30	..
	25	26	28	31	34
	30	28	30	34	37
	35	30	32	36	40
	40	32	34	38	43
	45	34	36	40	45
	50	36	38	42	47
	55	38	40	44	49
	60	39	41	46	52

Chestnut:

	Length of Poles, Feet.	Not Over 12 Wires, Inches.	Not Over 20 Wires, Inches.	Not Over 40 Wires, Inches.	Not Over 80 Wires, Inches.
Minimum Top Circumference.. ..		20	20	22	24[*]
Minimum Circumference 6 feet from Butt	20	24	27	..	..
	22	25	28½	31	..
	25	27	30	33	37
	30	31	33	36	40
	35	35	36	40	43
	40	39	40	43	45
	45	43	43	47	48
	50	46	46	50	51
	55	..	49	53	54
	60	..	..	56	57

Other Kinds:

Poles of other kinds of timber or other material and construction shall have at least the same strength and durability as those specified above.

6. Wire Loads.

Each aerial telegraph, telephone or signal wire shall be counted as one wire, without regard to size or kind, up to and including No. 8 B. W. G. Wires of larger size shall be considered as the number of No. 8 B. W. G. copper wires to which they are equivalent in weight. The number of aerial wires equivalent to a cable shall be determined by multiplying the circumference of the cable, in inches, by three (3).

Each twisted pair shall be considered as one wire and each messenger wire supporting twisted pair wiring shall be considered as one wire. Not more than two messenger wires shall be attached to either pole of the crossing span.

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[*] 55 and 60 foot poles to carry not over 80 wires, 22 inches.

7. Setting Poles.

Poles shall be set to the following depths:

Length of Poles, Feet.	Depth in Earth, Feet.	Depth in Solid Rock, Feet.
20	4	3
22	4½	3
25	5	3
30	5½	3½
35	6	4
40	6	4
45	6½	4½
50	7	4½
55	7½	5
60	8	5

Great care shall be taken to secure firm foundations. Exposure to washouts shall be avoided. Poles should not be set in a sloping bank, but if it be unavoidable, the depth of each hole shall be measured from the lowest side of the opening. When the slope of the bank is greater than 45 degrees, or when the earth is so soft that it is possible that the pole may press out of the bank, the pole shall be set 6 inches deeper than is specified in the above table. Wherever ordinary methods do not provide secure setting for poles, artificial foundations and extraordinary methods shall be used to secure stability.

Holes shall be dug large enough to admit the poles without stabbing or hewing, and shall be full size at the bottom to allow the use of tampers. The dirt shall be filled in evenly around the poles and thoroughly tamped as the holes are filled. Soil shall then be piled around the poles above the surface and firmly packed. Poles set in rock shall have the rock firmly wedged around them.

8. Fitting Poles.

The top of each pole shall be roofed.

On round poles gains shall be provided for all cross arms. They shall be of proper width for the cross arms used, and ½ inch deep.

The center of the upper gain shall be at least 10 inches below the apex of the roof.

9. Guys.

(a) Poles supporting the crossing span shall be side guyed in both directions, if practicable, and be head-guyed away from the crossing span. Braces may be used instead of guys.

(b) Guys shall be of galvanized steel wire or stranded steel cable, and their strength and number shall be as follows:

Number of Wires.	Strength and Number of Head Guys.	Strengh and Number of Side Guys.
1 to 2 inclusive	1 No. 6 B. W. G. steel wire	1 No. 6 B. W. G. steel wire each side.
3 to 12 inclusive	1 4,000 lbs.	1 4,000 lbs. each side.
13 to 14 inclusive	1 6,000 lbs.	1 6,000 lbs. each side.
41 to 50 inclusive	1 10,000 lbs. or 2 6,000 lbs.	1 6,000 lbs. each side.
51 to 80 inclusive	1 16,000 lbs. or 2 10,000 lbs.	1 10,000 lbs. or 2 6,000 lbs. each side.

Guys shall be attached to galvanized iron rods of the following dimensions:

Size of Guy.	Size of Guy Rod.
No. 6 B. W. G. steel wire	6 ft. x ½ inch
4,000 lbs. strand	6 ft. x ½ inch
6,000 lbs. strand	8 ft. x ⅝ inch
10,000 lbs. strand or two 6,000 lbs. strand	8 ft. x ⅝ inch
16,000 lbs. strand or two 10,000 lbs. strand	9 ft. x ¾ inch

(c) Anchor rods shall be fastened to anchor logs of sound materials. Excavations in earth for anchor logs shall be of the dimensions given in the following table, depending on the size of guy rods and anchor logs used:

Number of Guy Rods.	Size of Guy Rods.	Depth of Excavation for Anchor Logs.	Length and Breadth of Anchor Logs.
1	½ inch	4½ feet 4 feet	5 ft. x 6 inches
			5 ft. x 8 inches
			7 ft. x 6 inches
		3½ feet	5 ft. x 12 inches
			7 ft. x 9 inches
			9 ft. x 7 inches
1	⅝ inch	6 feet	5 ft. x 10 inches
			7 ft. x 7 inches
		5 feet	5 ft. x 16 inches
			8 ft. x 10 inches
		4 feet	5 ft. x 23 inches
			8 ft. x 14 inches
			10 ft. x 12 inches
2	⅝ inch	6 feet	5 ft. x 14 inches
			6 ft. x 12 inches
			7 ft. x 10 inches
		5 feet	6 ft. x 16 inches
			8 ft. x 14 inches
			9 ft. x 12 inches
3	⅝ inch	6 feet	6 ft. x 16 inches
			8 ft. x 14 inches
			9 ft. x 12 inches
1	¾ inch	6 feet	6 ft. x 12 inches

The length and width of each excavation shall be as small as possible, especially at the surface of the ground.

(d) Guy stubs may be used only where it is necessary to raise guys above obstacles or to prevent the obstruction of thoroughfares. They shall be good, strong poles. In no case shall the guy stub be smaller in diameter at the top than the pole it supports. They shall be set to lean away from the poles they reinforce, and shall be anchor guyed with guys equivalent to the pole guys of the poles they support except that when a stub cannot be anchored an extra large stub shall be used and it shall be set at least 6 feet in the ground and be braced by a footing or underground brace of proper dimensions.

In general, the method of anchoring, location of anchors and depth and character of setting shall be such as will render effective the full strength of the guy.

Guy anchors shall be placed at a distance from the poles they reinforce, measured at the ground line, of not less than one-third the height of the guy above the ground at the pole.

On poles carrying one or two cross-arms, both head and side guys shall be attached under the upper cross-arm. On poles carrying more than two cross-arms the first head guy shall be attached below the second cross-arm and successive head guys under the fourth and sixth cross-arms. On poles carrying more than two cross-arms, side guys shall be attached below the second cross-arm.

Stranded guys shall be attached to guy rods with thimbles and fastened as shown in the following table:

	Number of Clamps	
Kind of Strand.	Dead-Ended on Pole or Stub.	Dead-Ended on Thimble.
4,000 lbs.	1 two-bolt or 1 three-bolt	1 two-bolt or 1 three-bolt
6,000 lbs.	1 three-bolt	1 three-bolt
10,000 lbs.	2 three-bolt	2 three-bolt
16,000 lbs.	2 three-bolt	3 three-bolt

The end of the guy attached to the pole shall be wrapped twice around the pole, and the wrapping held in place on the back of the pole by staples or their equivalent.

(e) Braces shall have top dimensions not less than the top dimensions of the poles they reinforce. Each brace shall be set so that the "lead" will not be less than one-third the height of the brace above ground, measured horizontally at the ground line, of the pole supported, shall be attached to the pole it braces, for one arm, just below the first gain, for two arms, just below the second gain, for four arms or more, just below the fourth gain, and be fastened by a cross-arm bolt placed at the lower end of the heel bevel where the brace is in contact with the pole.

The butt of each push brace shall be set at least 3½ feet in the ground and be supported on planks, logs, large stones or solid rock ledge.

The butt of each push and pull brace shall be set to a depth of at least 6 feet in the ground and a cross log at least 5 feet long and not less than 8 inches in diameter shall be attached to it by a cross-arm bolt not less than 8 inches from the butt of the brace. When the pole carries more than 20 wires, 5 wraps of No. 8 B. W. G. galvanized iron wire shall be placed around the pole and brace immediately below their junction.

10. Cross-Arms.

(a) *Description.*—Wooden cross-arms shall be of sound material, preferably Western fir, of cross-section not less than 2¾ by 3¾ inches for 6-foot arms or shorter, 3 by 4¼ inches for arms longer than 6 feet. Other timber may be used provided it is equal to Western fir of these dimensions in strength and durability. Arms shall not exceed 10 feet in length and shall not support more than 10 wires.

(b) *Method of Attaching to Poles.*—Double cross-arms shall be used on all the poles supporting crossing spans and shall be so attached as to be maintained at right angles to the poles. Each pole shall be gained on both sides and each pair of cross-arms fastened to the pole with one ⅝-inch cross-arm or through bolt. Cross-arm braces must be attached to at least one of each pair of double cross-arms. Blocks of the same section as and preferably consisting of pieces of cross-arms or of iron pipe, of such length as to fit tightly, shall be placed between each pair of double arms and 8 inches from each end thereof, and secured in place by ⅝-inch cross-arm or through bolts extending through both arms and lengthwise through the blocks or pipes. Each bolt shall be provided with two square washers, one to be placed under the head of the bolt and the other between the nut and the cross-arm. When pipe is used two additional washers shall be provided, one to be placed at each end of the pipe.

(c) *Cross-Arm Braces.*—Cross-arm braces shall be steel or iron not less than 3/16 by 1 3/16 by 26 inches long, each secured to the pole by a fetter drive screw or lag bolt not less than 4 by ½ inches and to the cross-arm by a lag bolt not less than 2¼ inches long or a carriage bolt not less than 4 by ⅜ inches, except that when the arms are so spaced that the braces cannot be attached to the poles in this manner, they shall be fastened vertically to the arms at points situated two-thirds of the distance from the center of the pole to the end of the arm, and in addition a pair of braces shall be attached in the usual manner to the bottom arm and the pole.

11. Pins.

The pins used on the arms next to the crossing shall be of steel, combination wood and metal or locust.

(a) *Steel Pins.*—A steel pin may be a steel spindle 8⅝ by ½ inches, except shoulder, which is ⅝ inch with 1¼-inch base, together with round washer, nut and cap of split oak wood, or other device of equal strength and durability

(b) *Combination Wood and Metal Pins.*—A combination wood and metal pin may be a wooden pin, minimum diameter of shank 1¼ inches, maximum length 9 inches, with a hole bored lengthwise through its center, in which is inserted a ½-inch bolt, 10 inches long, equipped with a 1½-inch washer, or other device of equal strength and durability. The wood in the pin shall be equal to locust in strength and durability.

(c) *Locust Pins.*—Locust pins are to be of sound, straight-grain locust, minimum cross-section of shank 1¼ inches, maximum length 8 inches.

12. Hardware.

All pole-line hardware shall be galvanized; and when exposed to corrosive influences materially greater than those resulting from the action of the natural elements, steel pins shall be galvanized, or heavier pins than the standard specified in section 10 of these specifications shall be used. Galvanizing shall be applied in accordance with the specifications for galvanizing iron and steel.

13. Insulators.

Each insulator shall be of such pattern and design that when mounted it will withstand, without injury or without being pulled off the pin, the maximum stress to which it will be subjected with conductor attached, under the most unfavorable conditions of temperature and loading.

14. Wire.

(a) *Kinds and Sizes.*—The line wires in the crossing span and in the next adjoining span on each side thereof shall be of galvanized iron, hard-drawn copper, or of copper-covered steel of specifications satisfactory to the parties. Iron wire shall not be used where the exposure to corrosive influences is materially greater than that resulting from the action of the natural elements. The minimum size of wire which may be used at any crossing shall be as given in the following table:

Length of Crossing Span.	Galvanized Iron Wire.	Hard-Drawn Copper Wire.
150 feet or less.......	No. 10 B. W. G.	No. 10 B. & S.
151 feet or 175 feet...	No. 8 B. W. G.	No. 9 B. & S.

Twisted pair wire, when not supported by messenger wire, shall be of hard-drawn tinned copper, not smaller than No. 14 B. & S. gage, or of tinned copper-covered steel of specifications satisfactory to the parties, not smaller than No. 17 B. & S. gage. In no case shall twisted pair wire be used in spans longer than 100 feet without a messenger wire support.

No joint or splice shall be permitted in any of the crossing spans.

(b) *Sags.*—The minimum sag of wires in crossing spans shall correspond to the span length and the temperature at which it is strung, as specified in the following table:

	Temperature.						
Length of Span.	100° F, Inches.	80° F, Inches.	60° F, Inches.	40° F, Inches.	20° F, Inches.	0° F, Inches.	—20° F, Inches.
75 feet	4½	3	2½	2	2	1½	1
100 feet	7	5½	4½	4	3	2½	2
115 feet	9	7	5½	4½	3½	3	2½
125 feet	11	8½	7	6	5	4	3½
150 feet	14	11½	9	7½	6½	5½	5
175 feet	18	15	12	10	9	7½	6½

(c) *Method of Attaching.*—Each wire shall be attached to each insulator of its pair upon the double arm.

(d) *Ties.*—Tie wires for copper or copper-covered steel line wire shall be of the same gage as the line wire and of soft copper or of hard-drawn copper, which has been thoroughly annealed. Iron tie wires for No. 8 B. W. G. line wire or larger shall be No. 9 B. W. G. For smaller sizes of iron wire the tie wires shall be of the same gage as the line wires.

15. Cables.

(a) *Size of Strand.*—Galvanized steel stranded cable having a breaking strength of not less than 6,000 lbs. shall be used to support conductor cable of 50 pairs of No. 19 B. & S. gage copper wire, or its equivalent and smaller, of not less than 10,000 lbs. breaking strength for pairs in excess thereof up to 100 pairs No. 19 B. & S. gage copper wire, or its equivalent, and not less than 16,000 lbs. breaking strength for larger sizes.

(b) *Sag.*—Cables shall be suspended with minimum sag as follows:

Span in Feet.	Minimum Sag in Inches.
80 or less	16
90	20
100	22
110	26
120	30
130	34
140	40
150	44
175	62

16. Inspection.

Every facility for the inspection of the materials and workmanship shall be furnished the railroad company.

17. Maintenance.

The crossing shall be maintained in safe condition. The poles, cross-arms, insulators, guys, wires and other parts and materials used in the structure of the crossing shall be periodically inspected, and all defects shall be promptly repaired by the owner of the line. The guys and anchors shall be maintained so that the guys are kept taut and serve the purpose for which they are intended. The line wires shall be kept to the proper sag. Underbrush, grass, or other inflammable material shall be kept removed from the poles for a sufficient distance to reduce the fire hazard to the minimum.

SPECIAL COMMITTEE.

GRADING OF LUMBER.

[1] CLASSIFICATION AND GRADING RULES FOR DOUGLAS FIR.

1. The term "Douglas Fir" will cover the timber known likewise as Yellow Fir, Red Fir, Western Fir, Washington Fir, Oregon or Puget Sound Fir or Pine, Northwest and West Coast Fir.

2. *Fir Lumber* shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, except where otherwise expressly stipulated between buyer and seller.

3. Recognized defects in Fir are knots, knotholes, splits, checks, wane, rot, rotten streaks, wormholes, dog or picaroon holes, pitch seams, shake, pitch pockets, chipped grain, torn grain, loose grain, solid pitch, stained heart, sap stain and imperfect manufacture.

Knots.

4. Knots shall be classified as pin, small, standard and large, as to size; round and spike as to form, and tight, loose and rotten as to quality.

5. A pin knot is tight and not over ½-inch in diameter.

6. A small knot is tight and not over ¾-inch in diameter.

7. A standard knot is tight and not over 1½ inches in diameter.

8. A large knot is tight, and any size over 1½ inches in diameter.

9. A round knot is oval or circuar in form.

10. A spike knot is one sawn in a lengthwise direction.

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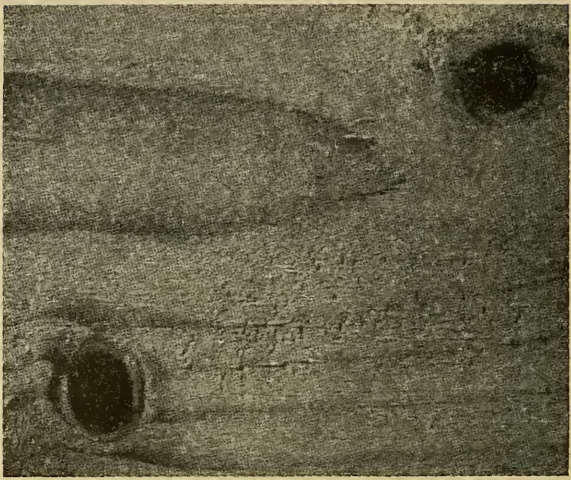
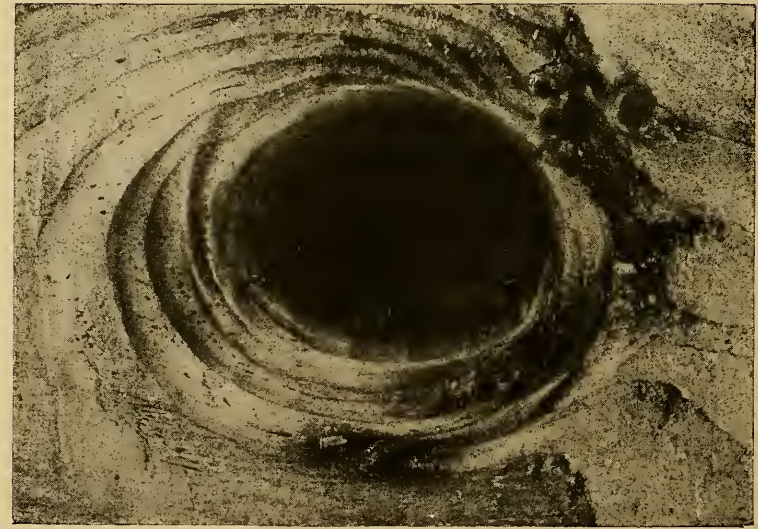
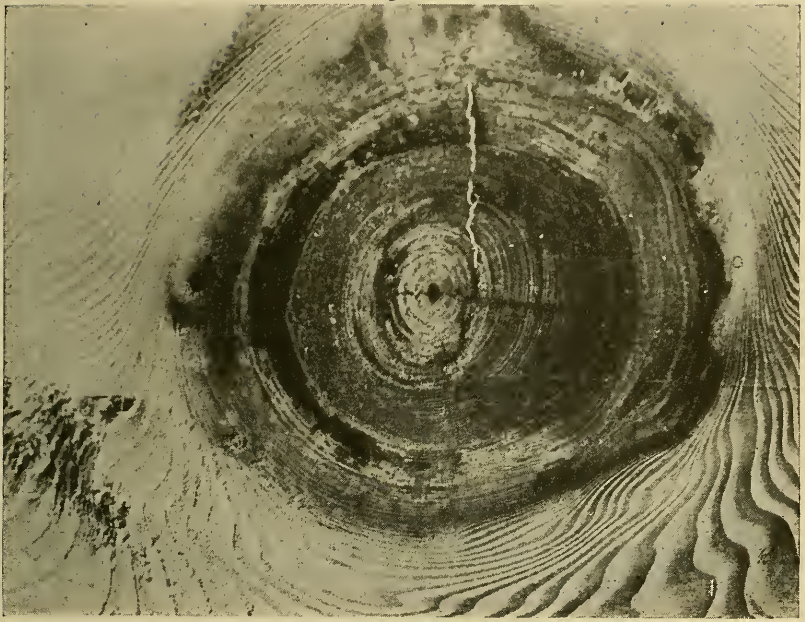
[1] Adopted, Vol. 12, Part 3, 1911, pp. 548-555; Vol. 13, 1912, pp. 873, 1053.



Pin Knot.



Standard Knot.



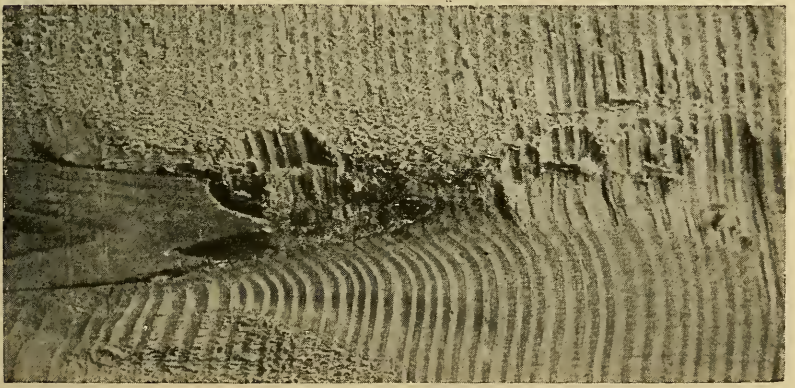
Large Knot.

The mean or average diameter of knots shall be considered in applying and construing these rules.

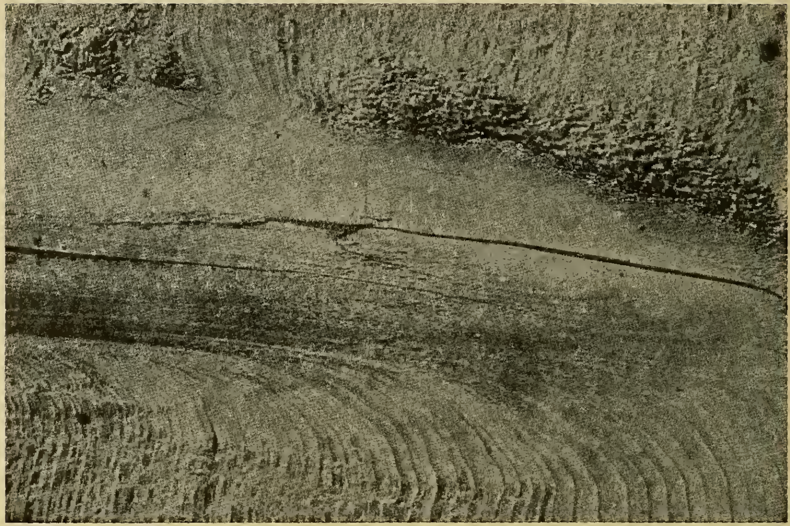
11. A tight knot or sound knot is one solid across its face, is as hard as the wood it is in, and is so fixed by growth or position that it will retain its place in the piece.

12. A loose knot is one not held firmly in place by growth or position.

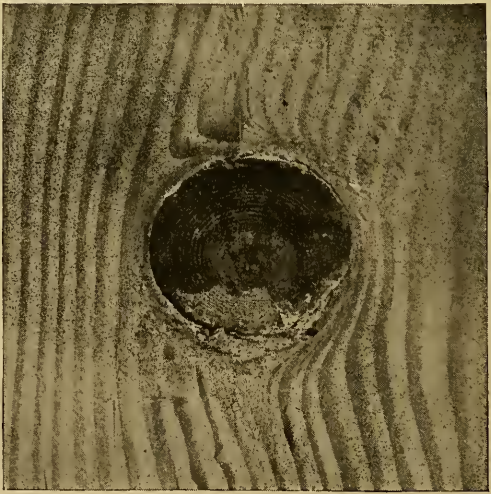
13. A rotten knot is one not as hard as the wood it is in.



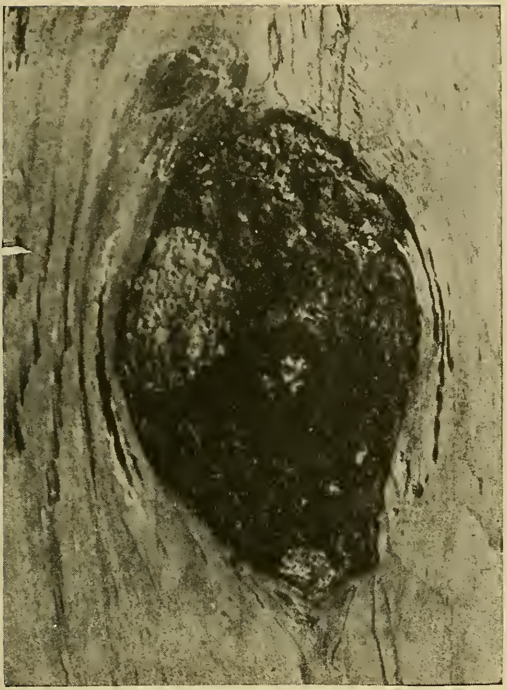
Small Spike Knot.



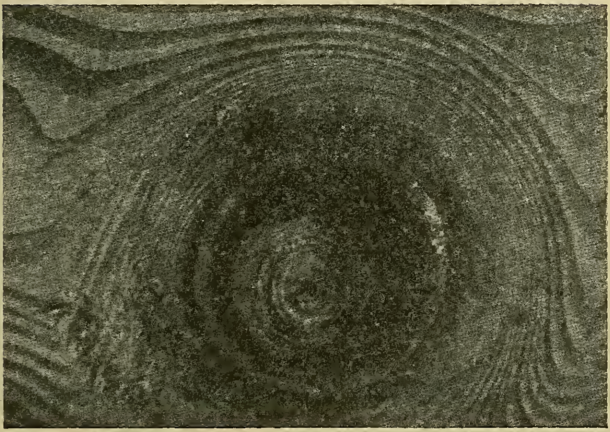
Large Spike Knot.



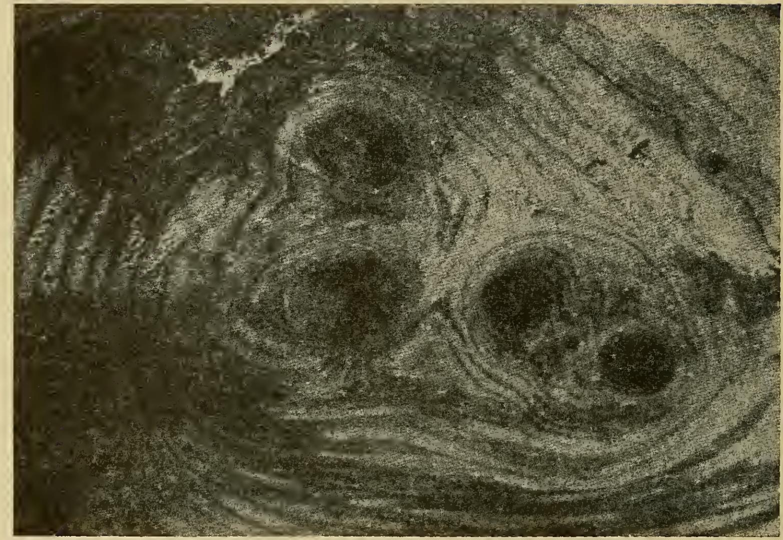
Loose Knot.



Rotten Knot.



Pitch Knot.



Cluster of Knots.

14. Pitch pockets are openings between the grain of the wood, containing more or less pitch and surrounded by sound grain wood; they shall be classified as small, standard and large pitch pockets.

15. A small pitch pocket is one not over ⅛-inch wide.

16. A standard pitch pocket is one not over ⅜-inch wide or 3 inches in length.

17, A large pitch pocket is one over ⅜-inch wide or over 3 inches in length.

Closed Small Pitch Pocket.

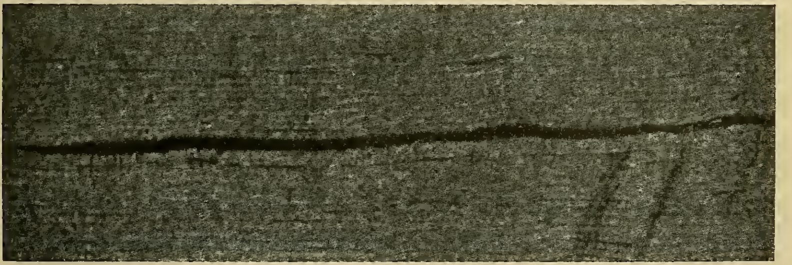
Solid Pitch.

18. A pitch shake or seam is a clearly defined opening between the grain of the wood and may be either filled with granulated pitch or not, but in either case is considered a defect in any of the grades hereinafter described.

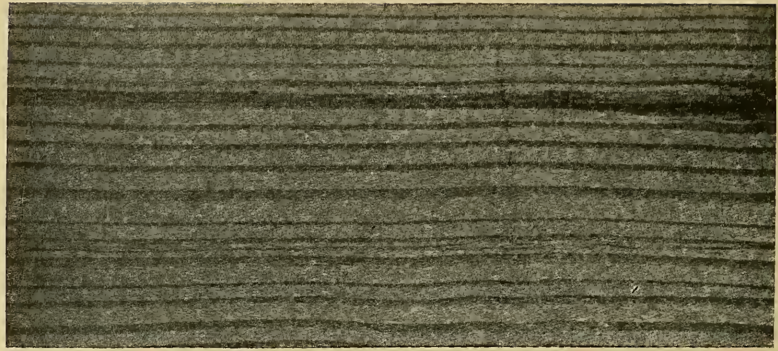
19. A pitch streak is a well-defined accumulation of pitch at one point in the piece, and when not sufficient to develop a well-defined streak, or where fiber between grains is not saturated with pitch, it shall not be considered a defect.

20. A small pitch streak shall be equivalent to not over one-twelfth the width and one-sixth the length of the piece it is in.

21. A standard pitch streak shall be equivalent to not over one-sixth the width and one-third the length of the piece it is in.



Large Open Pitch Pocket.



SMALL PITCH STREAK.

Wane.

22. Wane is bark, or the lack of wood, from any cause, on edge.

Sap.

23. Bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

24. Sap stain shall not be considered a defect, except as provided herein.

25. Discoloration of the heart of the wood, or stained heart, must not be confounded with rot or rotton streaks. The presence of rot is indicated by a decided softness of the wood where it is discolored or by small white spots resembling pin wormholes.

Miscellaneous.

26. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

27. All stock, except dimension, shall be inspected on the face side to determine the grade. Stock surfaced one side, the dressed surface shall be considered the face side. Stock rough or dressed two sides, the best side shall be considered the face, but the reverse side of all such stock shall not be more than one grade lower.

28. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found, should not be classed as torn grain, and shall be considered a defect only when it unfits the piece for use intended.

29. Torn grain consists of a part of the wood being torn out in dressing. It occurs around knots and curly places, and is of four distinct characters—slight, medium, heavy and deep.

30. Slight torn grain shall not exceed $\frac{1}{32}$-inch in depth; medium $\frac{1}{16}$-inch, and heavy $\frac{1}{8}$-inch. Any torn grain heavier than $\frac{1}{8}$-inch shall be termed deep.

31. Loosened grain consists in a point of one grain being torn loose from the next grain. It occurs on the heart side of the piece, and is a serious defect, especially in flooring.

32. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the coarsest piece such grades may contain, but the average quality of the grade shall be midway between the highest and lowest pieces allowed in the grade.

33. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

34. All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.

35. Equivalent means equal, and in construing and applying these rules, the defects allowed, whether specified or not, are understood to be equivalent in damaging effect to those mentioned applying to stock under consideration.

36. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or millwork will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

37. The term "Vertical Grain" is here used as synonymous with edge grain, rift-sawn, or quarter-sawed. The term "Flat Grain" is synonymous with slash grain or plain sawed.

BUILDING MATERIALS.

Flooring.

38. Defects based on piece 4 inches wide, 12 feet long, on all the following to and including Casing and Base, excepting where otherwise stated.

39. *No. 1 Clear.*—Vertical grain, 3, 4 and 6 inches. Shall be well milled on face, must have perfect edges and be practically free from all defects. Bright sap showing not more than one-third of face half the length of piece will be admitted. Angle of grain not less than 45 degrees.

40. *No. 2 Clear.*—Vertical grain, 3, 4 and 6 inches. Shall be well manufactured. Angle of grain not less than 45 degrees. Will admit of

slight roughness in dressing, and from one to three small, close pitch pockets, or equivalent defects.

A piece 14 feet or longer may have one defect located 6 feet or more from end of the piece, which can be cut out by wasting not more than 1½ inches in the length of the piece, provided balance of piece be practically free from other defects.

41 *No. 3 Clear.*—Vertical grain, 3, 4 and 6 inches. Angle of grain not less than 45 degrees. Will admit of roughness in dressing; two or three small knots not over ¾-inch in diameter, or eight small pitch pockets, any three of which may be open. It is generally understood that this grade will admit such defects or combination of defects as will not impair its utility for cheap floors.

A piece otherwise as good as No. 2 may have a defect that can be cut out and the piece laid with a loss of not more than 2½ inches in length, providing the defect is 4 feet or more from the end of the piece.

42. *No. 2 Clear and Better.*—Flat grain, 3, 4 and 6 inches. Shall be well manufactured; will admit of slight roughness in dressing. Either of the following also permitted with the above. Three close pitch pockets, not to exceed 2 inches each in length; three small, tight, smooth knots ½-inch in diameter, or their equivalent of combined defects.

A piece 14 feet or longer may have one defect, located 6 feet or more from the end of the piece, that can be cut out by wasting not more than 1½ inches of the length of the piece, provided balance of piece be practically free from other defects.

43. *No. 3 Clear.*—Flat grain, 3, 4 and 6 inches. Will admit of roughness in dressing; four small knots not over ¾-inch in diameter, or eight small pitch pockets, any three of which may be open, or without the above defects, three knots not over 1 inch in diameter, or the equivalent of combined defects.

A piece of otherwise as good as No. 2 can have a defect that can be cut out and the piece laid with a waste of not more than 2½ inches in its length, providing the defect is 4 feet or more from the end of the piece.

Vertical grain pieces that are a little below the line of No. 3 vertical grain will be admitted in this grade.

It is generally understood that this grade will admit such other defects or combinations of defects as will not impair its utility for cheap floors and sheathing.

Ceiling.

44. *No. 2 Clear and Better.*—3, 4 or 6 inches. Shall be well manufactured. Will admit of slight roughness in dressing. Either of the following also permitted with the above: Three close pitch pockets, not to exceed 2 inches each in length; three small, tight, smooth knots ½-inch in diameter, or their equivalent in combined defects. Both Vertical and Flat grain admissible.

A piece 14 feet or longer may have a defect located 6 feet or more from the end of the piece that can be cut out by wasting not more than 1½ inches in the length of the piece, provided balance of piece be practically free from other defects.

45. *No. 3 Clear.*—3, 4 or 6 inches. Allows any three of the following defects: Twenty-five per cent. of the face may be rough from dressing. Four-inch stock admits of not to exceed six tight knots ¾-inch in diameter, or two knots 1 inch in diameter, or three open pitch pockets not to 4 inches each in length, or an equivalent number of tight pitch pockets. Six-inch is correspondingly graded, with proportionately greater defects. Both Vertical and Flat grain admissible.

A piece otherwise as good as No. 2 may have a defect that can be cut out without wasting more than 2½ inches in length of the piece, providing it is more than 4 feet from the end.

Partition.

46. 4 or 6 inches. Shall be graded same as Ceiling on one face side, with the reverse side not more than one grade lower.

Porch Decking, Drop Siding and Rustic.

47. *No. 2 Clear and Better.*—4, 6 and 8 inches. Defects based on piece 6 inches wide, 12 feet long. Shall be well manufactured. Slight roughness in dressing admissible; will allow three small, tight knots not more than ½-inch in diameter, or four tight pitch pockets, or their equivalent of combined defects.

A piece 14 feet or longer may have one defect, located 6 feet or more from the end of the piece, that can be cut out by wasting not more than 1½ inches in the length of the piece, provided balance of piece be practically free from other defects.

48. *No. 3 Clear.*—4, 6 and 8 inches. Will admit of roughness in dressing; four or five knots not larger than 1 inch in diameter, or eight small pitch pockets, any three of which may be open, or their equivalent of combined defects.

A piece that is otherwise as good as No. 2 may have a defect that can be cut out by wasting not more than 2½ inches in the length of the piece, providing that it is more than 4 feet from the end of the piece.

Bevel Siding.

49. *No. 2 Clear and Better.*—4, 5 and 6 inches. Will admit of slight defects in dressing or two close pitch pockets or other minor defects, but each piece shall be suitable for use the full length without waste.

50. *No. 3 Clear.*—4, 5 and 6 inches. Will admit of small sound knots, small pitch pockets, roughness in dressing or other recognized defects, but not to exceed four of any of the said defects or their equivalent in any one piece.

Stepping.

51. *No. 2 Clear and Better.*—8 to 14 inches. Shall be well manufactured. Will allow chipped grain or slight torn grain on face and nosed edge, six close pitch pockets. With one of the above defects may have from one to three spike knots that do not show more than 2 inches on riser edge of the face side, or flat grain one-quarter of the face on the riser edge, or one small pitch pocket.

52. *No. 3 Clear.*—Will admit of medium torn grain, heavy torn grain or loose grain in two or three places; season checks that do not go through; stain covering one-fourth of the face of the piece. With any one of the above, one of the following or their equivalent of combined defects will be allowed; eight small pitch pockets or their equivalent of larger pockets; wane ½-inch deep on back edge, ½-inch wide on face; one standard pitch streak; six small knots; three 1-inch knots, or their equivalent of pin knots; two dog holes that do not go through; six picaroon or grubworm holes.

Finish.

53. *Selected Grain.*—1, 1¼, 1½ and 2 inches thick, 4 to 12 inches wide. Shall be free from sap and all defects on face and edges, and selected for beauty and character of grain.

54. *No. 2 Clear and Better.*—1, 1¼, 1½ and 2 inches thick, 4 to 12 inches wide. Based on 1 by 8-12. Rules to apply proportionately on narrower and wider stock. Will allow one straight split not exceeding the width of the piece; slight torn grain on face and edges; medium torn grain in one or two curly places; a small amount of stain. In addition to one of the above one of the following will be allowed: Three tight, smooth pin knots; one tight, smooth, small knot; three to five tight pitch pockets that do not go through the piece; one small pitch streak; three

picaroon holes not more than ¼-inch in diameter; two or three small kiln or seasoning checks or their equivalent of combined defects.

It is understood that this grade shall present a smooth surface after painting.

A piece 14 feet long or longer may have a defect located 4 feet or more from the end that can be cut out by wasting not more than 1½ inches in the length of the piece; provided balance of piece be practically free from defects.

55. *No. 3 Clear.*—1, 1¼, 1½ and 2 inches thick, 4 to 12 inches wide. Based on 1 by 8-12. Rules to apply proportionately on narrower and wider stock. Will admit of medium torn grain, heavy torn grain or loose grain in two or three places; season checks that do not go through; stain covering one-fourth of the face of the piece. With any one of the above, one of the following or their equivalent of combined defects will be allowed. Eight small pitch pockets or their equivalent of larger pockets; wane ½-inch deep on edge, ½-inch wide on face; one standard pitch streak; six small knots; three 1-inch knots, or their equivalent of pin knots; two dog holes that do not go through; six picaroon or grubworm holes.

Casing and Base.

56. To be graded same as Finish.

Tank Stock.

57. Must be water tight the full length of the piece, unless it is for cutting stock. Small knots, or pitch pockets which do not go through the piece, not to be considered defects. Edges to be practically clear or to contain no defects that will prevent a water-tight joint when worked.

Two-inch stock to contain practically no sap, 3-inch stock, when 12 inches wide, to allow 3 inches of sap on both edges of face side, not to extend over ¾-inch through the piece. Can be either vertical or slash grain.

Turned Porch Columns.

58. No. 1 Columns to grade 80 per cent. clear; the balance of 20 per cent. to admit of the following slight defects: Three small sound knots not over ¾-inch in diameter on the smooth part of the turned shaft, or on the square, or three tight pitch pockets, to be not over 3 inches long, or the equivalent in both knots and pitch pockets. Bright sap shall be no defect. The 5 by 5 and the 6 by 6 shall be bored through with not less than 1¾-inch bit.

The 4 by 4 to be bored through the square ends. The Colonial Columns shall be bored through with not less than 2-inch bit.

Boring to be at the option of the manufacturer.

Fencing.

59. Common Fencing must be manufactured from sound stock; may contain sound knots equal in diameter to not over one-third of the width of the piece, or spike knots the length of which is not over one-half of the width of the piece. May have wane ¼-inch deep on edge; not over 1 inch on face and one-quarter the length of the piece; torn grain; solid pitch; pitch pockets; stain, seasoning checks and a limited number of wormholes well scattered.

60. *One-inch Selected Common.*—4 to 12 inches. Shall be square edged. Will admit sound knots not over 1 inch in diameter in 4 inches and 6 inches, and not over 1½ inches in 8 inches to 12 inches, but located away from the edge; medium size pitch pockets and slight stain. But should be of sound, strong character.

Boards and Shiplap and D. & M.

61. *Common.*—Will admit of any two of the following, or their equivalent of combined defects: Wane ½-inch deep on edge, 1 inch wide on face, extending not over one-sixth of the length of the piece; stain; torn grain; pitch streaks; pitch pockets; seasoning checks; one straight split not longer than the width of the piece or a limited number of wormholes well scattered. These boards should be firm and sound and suitable for use in ordinary construction without waste.

62. *No. 3 Common Boards or Sheathing.*—Will admit of all stock below the grade of Common that is suitable for cheap sheathing and will allow: Coarse knots; knotholes; splits; rotten streaks; rotten sap, and any number of grub or pin worm holes.

Common Joist and Scantling.

63. *No. 1 Common.*—Generally speaking, this stock must be suitable and of sufficient strength for all ordinary construction purposes without waste. Will admit of coarser knots than 1 inch. Common, which in a 2 by 4 should not be larger than 2 inches. Spike knots not over two-thirds the width of the piece, wane not over ½-inch deep on edges and 1 inch wide on face, up to 2 by 6, and ½-inch deep on edge and 1½ inches wide on face on 2 by 8 and wider, extending not more than one-quarter the length of the piece; stain, solid pitch, pitch pockets, season checks, one straight split not more than the width of the piece, 2 or 3 grubworm holes, a limited number of pin wormholes and torn grain.

64. *No. 2 Common.*—This grade must be suitable for use without waste in a cheaper class of construction than common. Will allow coarse and unsound knots and knotholes that do not unfit the piece for use intended, rotten streaks, pitch seams, pitch pockets, a reasonable amount of rotten sap and pinworm holes, a few grubworm holes well scattered. It is understood that no culls or stock that will not work without waste will be allowed in this grade.

Common Timbers.

65. *No. 1 Common.*—Rough timbers, 4 by 4 and larger, shall not be more than ¼-inch scant when green, and be evenly manufactured from sound stock, and must be free from knots that will materially weaken the piece.

Timbers 10 by 10 in size may have a 2-inch wane on one corner, or its equivalent on two or more corners, one-fourth the length of the piece. Other sizes may have proportionate defects. Season checks and checks extending not over one-eighth the length of the piece admissible.

66. *No. 2 Common Timber.*—This is a grade of timber that will admit of large, loose or rotten knots, shakes or rot that do not impair its utility for temporary work. Hemlock and white fir will not be allowed in this grade.

Selected Common.

67. 2 by 4 to 2 by 12 and 3 by 4 to 4 by 6 shall be square edged. Will admit any quantity of sound knots, not over 1 inch in diameter, or small pitch pockets not over 4 inches in length. Sizes larger than 4 by 6 will admit sound knots not to exceed 1½ inches in diameter; pitch pockets not to exceed 6 inches in length.

It is understood that this is Selected Common, a grade lower than No. 3 Clear, and not to be confused with it.

Standard Sizes.

68. In the absence of a special agreement between the buyer and seller for each order, all dressed lumber is finished to the following sizes:

FLOORING.

1 by 3	Finished Size $\frac{13}{16}$ by 2¼ face
1 by 4	Finished Size $\frac{13}{16}$ by 3¼ face
1 by 6	Finished Size $\frac{13}{16}$ by 5⅛ face
1¼ by 4	Finished Size 1$\frac{1}{16}$ by 3¼ face
1¼ by 6	Finished Size 1$\frac{1}{16}$ by 5⅛ face

CEILING.

⅜ by 4	Finished Size	5/16 by 3¼ face
⅜ by 6	Finished Size	5/16 by 5⅛ face
½ by 4	Finished Size	7/16 by 3¼ face
½ by 6	Finished Size	7/16 by 5⅛ face
⅝ by 4	Finished Size	9/16 by 3¼ face
⅝ by 6	Finished Size	9/16 by 5⅛ face
1 by 4	Finished Size	11/16 by 3¼ face
1 by 6	Finished Size	11/16 by 5⅛ face

PARTITION.

1 by 4	Finished Size	11/16 by 3¼ face
1 by 6	Finished Size	11/16 by 5⅛ face

SHIPLAP AND D. & M.

1 by 8	Finished Size	¾ by 7 face
1 by 10	Finished Size	¾ by 9 face
1 by 12	Finished Size	¾ by 11 face

DROP SIDING.

1 by 4	Finished Size	¾ by 3¼ face
1 by 6	Finished Size	¾ by 5⅛ face
1 by 8	Finished Size	¾ by 7 face

RUSTIC.

1 by 6	Channel, Finished Size	¾ by 4⅞, ½-inch Rabbet
1 by 8	Channel, Finished Size	¾ by 6¾, ½-inch Rabbet
1 by 6	V. Finished Size	¾ by 4⅞, ½-inch Rabbet
1 by 8	V. Finished Size	¾ by 6¾, ½-inch Rabbet

DIMENSIONS, S1S1E OR S4S.

2 by 4 to 1⅝ by 3⅝
2 by 6 to 1⅝ by 5⅝
2 by 8 to 1⅝ by 7½
2 by 10 to 1⅝ by 9½
2 by 12 to 1⅝ by 11½
3 by 6 to 2½ by 5½
3 by 8 to 2½ by 7½
3 by 10 to 2½ by 9½
3 by 12 to 2½ by 11½

TIMBERS, S1S1E OR S4S.

4 by 4 and larger, ½-inch off each way.

FINISHING, THICKNESS S1S OR S2S.

1 inch to ¾
1¼ inches to 1 1/16
1½ inches to 1 5/16
2 inches to 1¾

WIDTHS, IF DRESSED ON ONE OR BOTH EDGES.

4 inches to 3½ inches
5 inches to 4½ inches
6 inches to 5½ inches
8 inches to 7¼ inches
10 inches to 9¼ inches
12 inches to 11¼ inches
14 inches to 13 inches
16 inches to 15 inches

COMMON BOARDS AND SHEATHING.

S1S or S2S to ¾-inch.

GROOVED ROOFING.

¾-inch by 7¼, 9¼, 11¼-inch face, ½-inch Groove, 1½ inches from each edge.

BEVEL SIDING.

6 inches—$\frac{3}{16}$-inch thin edge. ½-inch thick edge. 5½ inches wide.
4 inches—Same thickness, 3½ inches wide.

PICKETS.

1¼ inches square, $1\frac{1}{16}$ by $1\frac{1}{16}$ inches S4S.
1½ inches square, $1\frac{5}{16}$ by $1\frac{5}{16}$ inches S4S.
1 by 3 flat, ¾ by 2¼ inches S4S.

STANDARD LATH.

⅓-inch by 1½ by 4 feet.

Battens.

Are usually made of edges of good, sound stock and worked to the following sizes:

3 inches Flat to $\frac{5}{16}$ by 2½ inches.
2 inches OG to ¾ by 1¾ inches.
2½ inches OG to ¾ by 2¼ inches.
3 inches OG to ¾ by 2½ inches.

[2] CLASSIFICATION, GRADING RULES AND DRESSING RULES FOR SOUTHERN YELLOW PINE.

1. *Southern Yellow Pine.*—To cover Longleaf and Shortleaf Yellow Pine grown in the Southern States.

2. Southern Yellow Pine Lumber shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, except where otherwise expressly stipulated between buyer and seller.

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[2] Adopted, Vol. 12, Part 3, 1911, pp. 578-600; Vol. 13, 1912, pp. 874, 1053.

3. Recognized defects in Southern Yellow Pine are knots, knot holes, splits (either from seasoning, ring hearts or rough handling), shake, wane, red heart, pith, rot, rotten streaks, dote, worm holes, pitch streaks, pitch pockets, torn grain, loosened grain, seasoning or kiln checks and sap stains and imperfect manufacture.

Knots.

4. Knots shall be classified as pin, standard and large, as to size; and round and spike, as to form; and as sound, loose, encased, pith and rotten, as to quality.

5. A pin knot is sound and not over ½-inch in diameter.

6. A standard knot is sound and not over 1½ inches in diameter.

7. A large knot is one any size over 1½ inches in diameter.

8. A round knot is oval or circular in form.

9. A spike knot is one sawn in a lengthwise direction.

The mean or average diameter of knots shall be considered in applying and construing these rules.

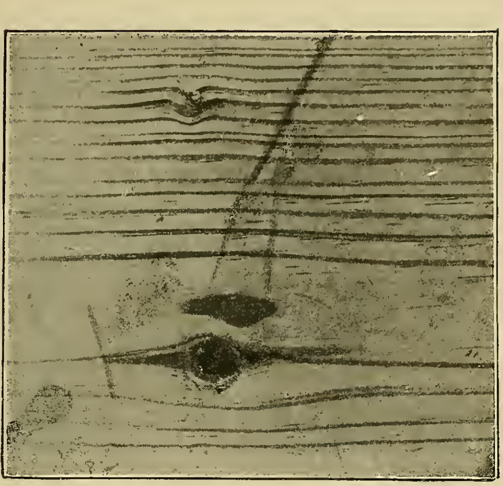
10. A sound knot is one solid across its face; is as hard as the wood it is in and so fixed by growth or position that it will retain its place in the piece.

11. A loose knot is one not held firmly in place by growth or position.

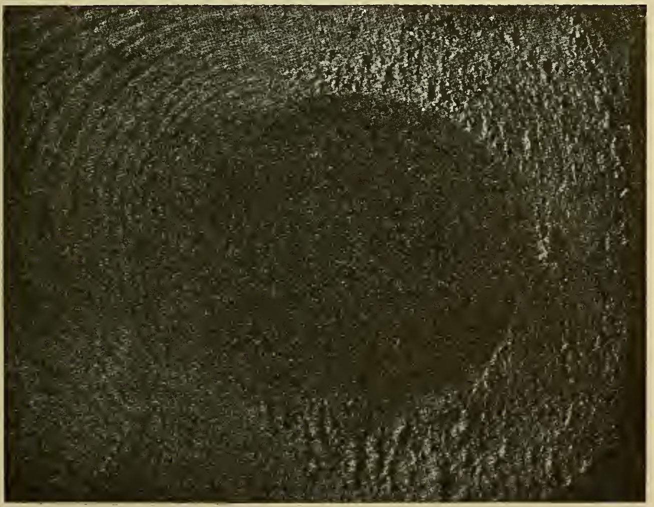
12. A pith knot is a sound knot with a pith hole not more than ¼-inch in diameter.

13. An encased knot is one surrounded wholly or in part by bark or pitch. Where the encasement is less than ⅛-inch in width on both sides, not exceeding one-half the circumference of the knot, it shall be considered a sound knot. (See Sections 10 and 17.)

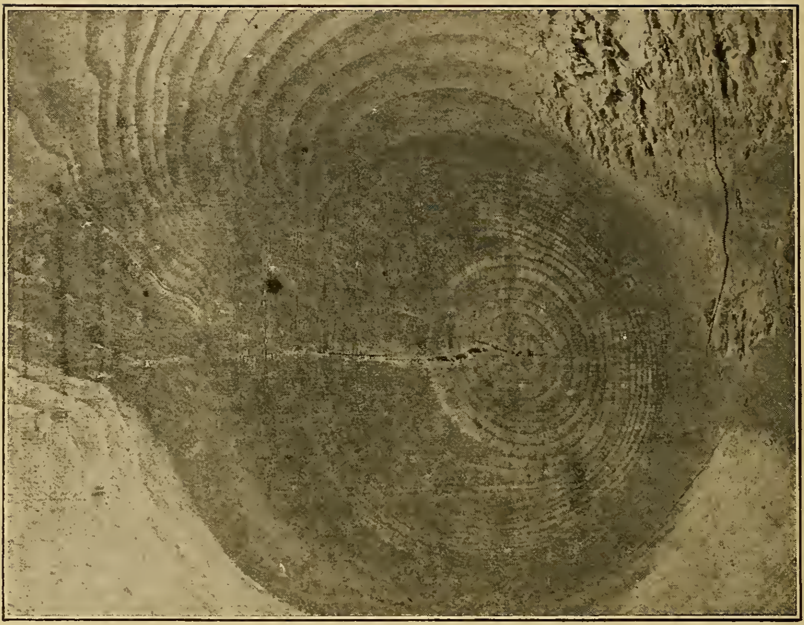
14. A rotten knot is one not as hard as the wood it is in.



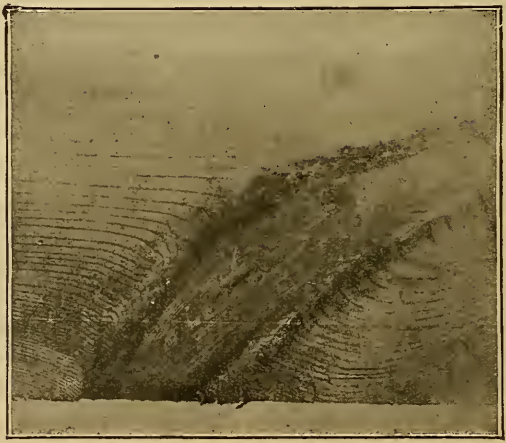
Pin Knot.



Standard Knot.



Large Knot.



Spike Knot.

Pitch.

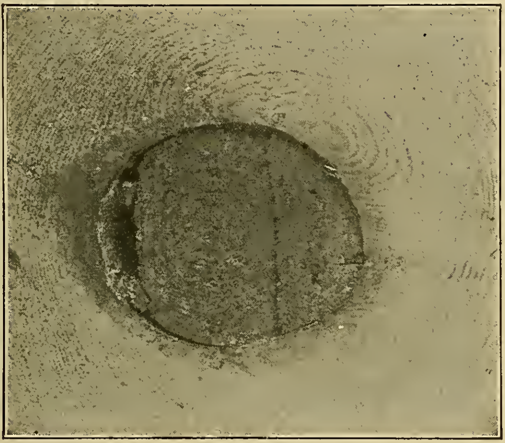
15. Pitch pockets are openings between the grain of the wood containing more or less pitch or bark, and shall be classified as small, standard and large pitch pockets.

16. A small pitch pocket is one not over ⅛-inch wide.

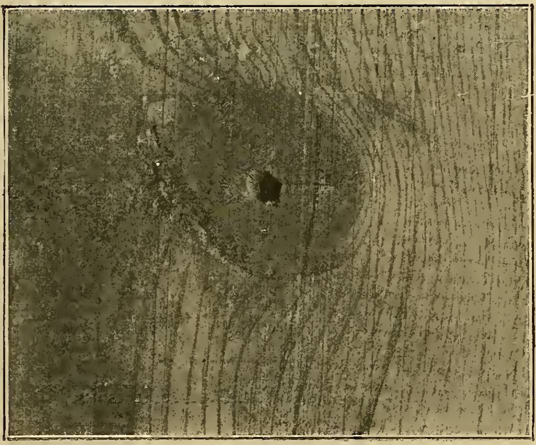
A standard pitch pocket is one not over ⅜-inch wide or 3 inches in length.

A large pitch pocket is one over ⅜-inch wide or over 3 inches in length.

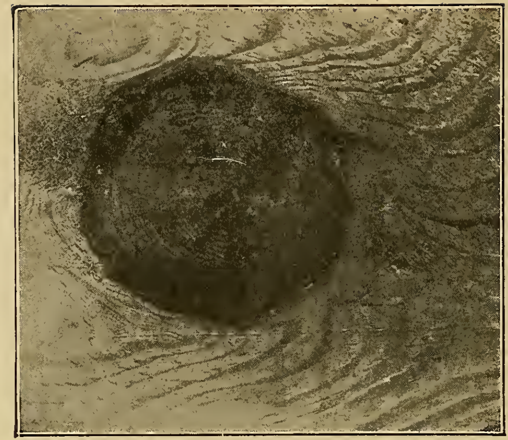
17. A pitch pocket showing open on both sides of the piece ⅛-inch or more in width shall be considered the same as a knot hole.



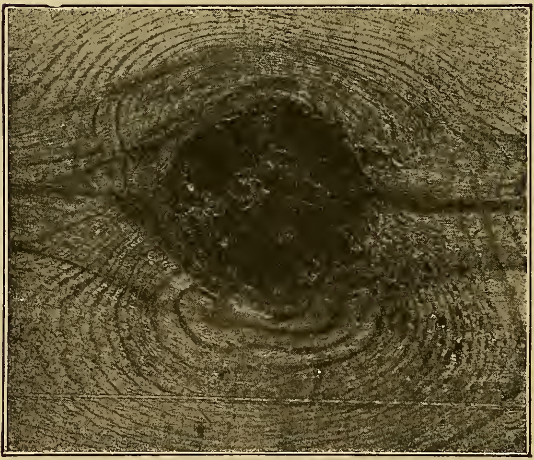
Loose Knot.



Pith Knot.



Encased Knot.



Rotten Knot.

18. A pitch streak is a well-defined accumulation of pitch at one point in the piece, and when not sufficient to develop a well-defined streak, or where fiber between grains is not saturated with pitch, it shall not be considered a defect.

19. A small pitch streak shall be equivalent to not over one-twelfth the width and one-sixth the length of the piece it is in.

A standard pitch streak shall be equivalent to not over one-sixth the width and one-third the length of the piece it is in.

Wane.

20. Wane is bark, or the lack of wood, from any cause, on edge.

Sap.

21. Bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

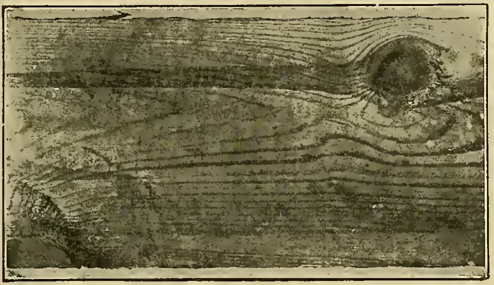
Shake.

22. Shakes are splits or checks in timbers which usually cause a separation of the wood between annual rings.

Through Shake.—A shake which extends between two faces of a timber.

Ring Shake.—An opening between the annual rings.

23. Sap stain shall not be considered a defect in any of the grades of Common Lumber.



Pitch Streak.

Miscellaneous.

24. Firm red heart shall not be considered a defect in any of the grades of Common Lumber.

25. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

26. All stock except Dimension shall be inspected on the face side to determine the grade. Stock surfaced one side, the dressed surface shall be considered the face side. Stock rough or dressed two sides, or common boards CM or shiplapped and S2S, the best face shall be considered the face side, but the reverse side of all such stock should not be more than one grade lower.

27. Imperfect manufacture in dressed stock, such as torn grain, loosened grain, slight skips in dressing, wane, broken knots, mismatched, insufficient tongue or groove Flooring, Ceiling, Drop Siding, etc., shall

be considered defects, and will reduce grade according as they are slight or serious in their effects on the use of the stock.

28. Pieces of Flooring, Drop Siding or Partition with $\frac{3}{16}$-inch or more of tongue; and pieces of Ceiling with ⅛-inch or more of tongue; and pieces of Shiplap with $\frac{5}{16}$-inch of lap will be admitted in any grade. Pieces of Flooring, Drop Siding, Ceiling or Partition, having not less than $\frac{1}{16}$-inch tongue will be admitted in No. 2 Common. Pieces of Shiplap having less than $\frac{5}{16}$-inch and not less than ⅛-inch lap shall be admitted in No. 2 Common.

29. In all grades D and better, Flooring, and No. 1 Common and better, Ceiling, Drop Siding, etc., wane on the reverse side, not exceeding one-third the width and one-sixth the length of any piece, provided the wane does not extend into the tongue, nor over one-half the thickness below the groove, is admissible.

30. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found should not be classed as torn grain and shall not be considered a defect.

31. Torn grain consists in a part of the wood being torn out in dressing. It occurs around knots and curly places, and is of four distinct characters—slight, medium, heavy and deep.

Slight torn grain should not exceed $\frac{1}{32}$-inch in depth, medium, $\frac{1}{16}$-inch and heavy ⅛-inch. Any torn grain heavier than ⅛-inch shall be termed deep.

32. Loosened grain consists in a point of one grain being torn loose from the next grain. It occurs on the heart side of the piece, and is a serious defect, especially in Flooring.

33. The grade of all regular stock shall be determined by the number, character, position and location of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the coarsest pieces such grades may contain.

34. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended. Material not conforming to standard sizes, for Agricultural Implement Companies, Wagon Companies, Car Manufacturing Companies, Railway Companies, etc., shall be governed by special contract and inspection.

35. The standard lengths are multiples of 2 feet, 10 to 24 feet inclusive, for Boards, Fencing, Dimension, Joists and Timbers; multiples of 1 foot, 10 to 20 feet, inclusive, for Finishing, Flooring, Ceiling, Siding, Partition, Casing, Base Window and Door Jambs—except as herein-

after specified. Longer or shorter lengths than those herein specified are special. Special and fractional lengths, when ordered, shall be counted as the next higher standard length.

36. The standard of widths for lumber, S1S or S2S or rough, excluding Dimension, shall be multiples of 1 inch—3 inches and up in width.

37. On stock width shipments of No. 1 Common and Better lumber, either rough or dressed one or two sides, no piece should be counted as of standard width that is more than ¼-inch scant or 8-inch and under ⅜-inch scant on 9 and 10 inches, or ½-inch scant on 11 and 12 inches or wider. Such pieces should be measured as the next lower standard of width and not reduced in grade.

38. Yellow pine shall be classified as to grain as Edge Grain and Flat Grain. Edge Grain has been variously designated as rift sawn, vertical grain, quarter sawn, all being commercially synonymous terms. Edge grain stock is especially desirable for Flooring and admits no piece in which the angle of the grain exceeds 45 degrees from vertical at any point, thus excluding all pieces that will sliver or shell from wear. Such as will not meet these requirements shall be known as Flat Grain.

39. All dressed stock shall be measured and sold strip count, viz.: full size of rough material necessarily used in its manufacture.

All sizes 1 inch or less in thickness shall be counted as 1 inch thick.

40. In standard manufacture of Factory Flooring, Decking or thick dressed and matched stock, and stock grooved for splines, and for thick Shiplap, the finished width shall be ½-inch less over all than the count or measured width of the rough material used in manufacture, and the tongue and lap shall be measured to determine the finished width, and face measures shall no longer be standard.

41. Equivalent means equal, and in construing and applying these rules, the defects allowed, whether specified or not, are understood to be equivalent in damaging effect to those mentioned applying to stock under consideration.

No arbitrary rules for the inspection of lumber can be maintained with satisfaction. The variations from any given rule are numerous and suggested by practical common sense, so nothing more definite than the general features of different grades should be attempted by rules of inspection. The following, therefore, are submitted as the general characteristics of the different grades.

Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or mill work will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

BRIDGE AND TRESTLE TIMBERS.

(See under "Wooden Bridges and Trestles.")

BUILDING LUMBER.

Dressed Yellow Pine Finishing.

43. *Sizes.*—Finishing shall be dressed in the following: 1 inch S1S or 2S to 13/16; 1¼ inches S1S or 2S to 1 1/16; 1½ inches S1S or 2S to 1 5/16; 2 inches S1S or 2S to 1¾ inches. 1 by 4—S4S shall be 3½ inches wide finished; 1 by 5—S4S shall be 4½ inches wide; 1 by 6—5½ inches; 1 by 7—6½ inches; 1 by 8—7½ inches; 1 by 9—8½ inches; 1 by 10—9½ inches; 1 by 11—10½ inches; 1 by 12—11¼ inches. The foregoing widths shall also apply to stock thicker than 1 inch.

44. *Widths.*—On stock width shipments of all finishing Lumber, either rough or dressed one or two sides, no piece shall be counted as standard width that is more than ¼-inch scant on 8 inches and under; ⅜-inch scant on 9 or 10 inches, or ½-inch scant on 11 or 12 inches or wider. Such pieces should be measured as of the next lower standard of width and not reduced in grade.

45. *Lengths.*—Standard lengths are 10 to 20 feet, and in shipments of mixed lengths, 5 per cent. of 8 or 9 feet in grade of C and better shall be admitted.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of feet of each length in such shipment be specifically stated.

Grades A, B and C.

46. *A Finishing.*—Inch, 1¼, 1½ and 2 inches dressed one or two sides, up to and including 8 inches wide, must show one face practically clear of all defects, 9 or 10 inches wide, in addition to one split in end not more than 6 inches long, will admit any one of the following defects: One small pitch pocket; one pin knot; pitch streak or sap stain not to exceed the equivalent of 6 square inches. One-third of any shipment of 11 and 12 inches, in addition to one split in each which should not exceed in length the width of the piece, will admit any one of the following defects or its equivalent: Three pin knots; one standard knot; three small pitch pockets; one standard pitch pocket; one small pitch

streak; small seasoning checks; sap stain 1½ inches wide running across the face of the piece.

Thirteen inches and wider will admit two of the above defects or their equivalent. Pieces otherwise admissible, which have loosened or torn grain on the face side, shall be put in a lower grade.

47. *B Finishing.*—Inch, 1¼, 1½ and 2 inches dressed one or two sides up to and including 10 inches in width, in addition to one split in end which should not exceed in length the width of the piece, will admit any two of the following or their equivalent of combined defects: Slight torn grain; three pin knots; one standard knot; three small pitch pockets; one standard pitch pocket; one standard pitch streak; 5 per cent. of sap stain; wane not to exceed 1 inch in width, ¼-inch in depth and one-sixth the length of the piece; small seasoning checks.

Eleven inches and wider will admit three of the above defects or their equivalent; but sap stain shall not exceed 10 per cent.

48. *C Finishing.*—Up to and including 10 inches in width will admit in addition to one split in end which should not exceed in length the width of the piece, any two of the following or their equivalent of combined defects; 25 per cent. of sap stain; 25 per cent. firm red heart; two standard pitch streaks; medium torn grain in three places in one piece; slight shake; seasoning checks that do not go through; two standard pitch pockets; six small pitch pockets; two standard knots; six pin knots; wane 1 inch in width, ½-inch in depth and one-third the length of the piece. Defective dressing will also be allowed that does not prevent its use as finish without waste; 11 and 12 inches will admit one additional defect or its equivalent. Pieces wider than 12 inches will admit two additional defects to those admitted in 10 inches or their equivalent, except sap stain, which shall not be increased.

Pieces otherwise good as B will admit of 20 wormholes.

49. *Special.*—In case both sides are desired A, B or C Grade or free from all defects, special contract must be made. Defective dressing or slight skips in dressing on the reverse side of Finishing are admissible.

50. *Panel Shop.*—Panel shop is 10 inches and 12 inches wide, all lengths from 8 to 20 feet or longer. Must be practically free from pitch streaks. May contain any kind of defects that can be removed by cross-cutting the board. Such defects must be limited in number and location so that cross-cutting to remove them will not use more than one-quarter of the length of the piece, and the residue of the piece shall be suitable for No. 1 and No. 2 panel, and all lengths 18 inches and longer, but such residue shall not be considered to be of any special stock length,

but will represent the balance of the board after the defects as above named have been removed.

Flooring.

51. *Sizes.*—D and better, 1 by 3, 1 by 4 and 1 by 6 inches shall be worked to $\frac{13}{16}$ by 2¼, 3¼ and 5¼ inches; 1¼-inch Flooring shall be worked to $1\frac{3}{32}$ inches thick; 1½-inch Flooring to $1\frac{11}{32}$ inches thick, the same width and the same matching as 1-inch stock.

52. *Lengths.*—Standard lengths are 8 to 20 feet in B and Better Flooring with not to exceed 5 per cent. of 8-foot lengths in mixed length shipments of this grade and in addition 5 per cent. of 6 or 7 feet in C, D, and No. 1 Common, and in addition 5 per cent. of 4 or 5 feet in No. 2 Common.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of feet of each length in such shipments be specifically stated.

53. *Grades.*—A, B, C, D, No. 1 Common, No. 2 Common and No. 3 Sheathing, Flat Grain; and A, B, C, D and No. 1 Common Edge Grain.

54. *Special Section.*—Defects named in Flooring are based upon a piece manufactured from 1 by 4—12, and pieces larger or smaller than this will take a greater or less number of defects, proportioned to their size on this basis. Except that standard knots shall not exceed 1¼ inches in diameter in 3-inch flooring.

55. A Flat Flooring must be practically free from defects on the face side and well manufactured.

56. B Flat Flooring will admit any two of the following or their equivalent of combined defects; 15 per cent. sap stain; 15 per cent. firm red heart; three pin knots; one standard knot; three small pitch pockets; one standard pitch pocket; one standard pitch streak; slight torn grain; small seasoning checks; six pin wormholes.

57. C Flat Flooring will admit any two of the following defects or their equivalent of combined defects: 25 per cent. of sap stain; 25 per cent. firm red heart; two standard pitch streaks; medium torn grain, or other machine defects that will lay without waste; slight shake that does not go through or seasoning checks that do not go through; two standard pitch pockets; six small pitch pockets; two standard knots or six pin knots; 12 pin wormholes.

58. Edge Grain Flooring shall take the same inspection as Flat Grain, except as to the angle of the grain.

59. Heart Face Edge Grain shall be free from sap on face side.

60. D Flat Flooring will admit the following defects or their equivalent of combined defects: Sound knots not over one-half the cross section of the piece in the rough at any one point throughout its length; three pith knots; pitch; pitch pockets; sap stain; firm red heart; seasoning checks that do not go through; shake that does not go through; a limited number of pin wormholes well scattered; loosened or heavy torn grain, or other machine defects that will lay without waste.

Pieces otherwise as good as B may have one defect (like a knot hole) that can be cut out by wasting 1½ inches of the length of the piece, provided both pieces are 16 inches or over in length after cutting out such defects.

61. No. 1 Common Flooring is the combined grade of C and D flooring and will admit all pieces that will not grade B and are better than No. 2 Common.

62. No. 2 Common Flooring admits all pieces that will not grade as good as D Flooring, that can be used for cheap floors without a waste of more than one-fourth the length of any one piece.

63. No. 3 Sheathing will admit of all pieces that cannot be used as No. 2 Common Flooring, but are still available as cheap sheathing or lathing without a waste of more than one-fourth the length of any one piece.

64. Center Matched Flooring shall be required to come up to grade on face side only, and the defects admissible on the reverse side of standard matched shall be allowed.

Ceiling.

65. *Sizes.*—Ceiling shall be worked to the following: ⅜-inch Ceiling, $\frac{5}{16}$-inch; ½-inch Ceiling, $\frac{7}{16}$-inch; ⅝-inch Ceiling, $\frac{9}{16}$-inch; ¾-inch Ceiling, $\frac{11}{16}$-inch. Same width as Flooring. The bead on all Ceiling and partition shall be depressed $\frac{1}{32}$ of an inch below surface line of piece.

66. *Lengths.*—Standard lengths are 10 to 20 feet. 5 per cent. of 8 or 9 feet is allowed in mixed length shipments of B and better Ceiling, and in addition 5 per cent. of 6 or 7 feet in No. 1 Common, and in addition 5 per cent. of 4 or 5 feet in No. 2 Common.

The above per cent. is allowed on all shipments of mixed lengths, even though the number of feet of each length in such shipment be specifically stated.

67. *Grades.*—A, B, No. 1 and No. 2 Common.

68. *Special Section.*—Defects named in Ceiling are based upon a piece manufactured from 1 by 4—12, and pieces larger or smaller than

this will take a greater or less number of defects, proportioned to their size on this basis.

69. A Ceiling must be practically free from defects on the face side, and well manufactured.

70. B Ceiling will admit of any two of the following defects or their equivalent of combined defects: Slight torn grain; three pin knots; one standard knot; three small pitch pockets; one standard pitch pocket; one small pitch streak; small seasoning checks; 15 per cent. sap stain; 15 per cent firm red heart; 6 pin wormholes.

71. No. 1 Common Ceiling will admit the following defects or their equivalent of combined defects: Sound knots not over one-half the cross-section of piece in the rough; sap stain; pitch streaks; pitch pockets; firm red heart; slight shake; heavy torn grain; seasoning checks; defects in manufacture that will lay without waste; a limited number of pin wormholes, well scattered.

Pieces otherwise as good as B may have one defect (like a knot hole) that can be cut out by wasting 1½ inches of the length of the piece, provided both pieces are 16 inches or over in length after cutting out such defects.

72. No. 2 Common Ceiling admits of all pieces not as good as No. 1 Common that can be used without waste of more than one-fourth the length of any one piece.

Wagon Bottoms.

Sizes.—Unless otherwise ordered, shall be made in sets 38 and 42-inch face and from stock 4 inches or over in width. Standard thickness shall be $\frac{13}{16}$-inch.

Grades.—A and B. 58. Wagon bottoms, unless otherwise ordered, shall be graded the same as A and B Flat Flooring.

Drop Siding.

73. *Sizes.*—D&M shall be worked to ¾ by 3¼ and 5¼-inch face, 5½ inches over all. Worked Shiplap, to ¾ by 5-inch face, 3½ and 5½ over all. Patterns that are not shown in Yellow Pine Manufacturers' Association Moulding Book of January, 1908 edition, are considered special.

74. *Lengths.*—Standard lengths 10 to 20 feet. Five per cent. of 8 or 9 feet is allowed in mixed length shipments of B and better Drop Siding, and in addition 5 per cent. of 6 or 7 feet in No. 1 Common and in addition 5 per cent. of 4 or 5 feet in No. 2 Common.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of feet of each length in such shipment be specifically stated.

75. *Grades.*—A, B, No. 1 and No. 2 Common.

76. *Special Section.*—Defects named in Drop Siding are based upon a piece manufactured from 1 by 6—12 feet and pieces larger or smaller than this will take a greater or less number of defects, proportioned to their size on this basis.

77. For Grades of 8-inch Barn Siding, see Secs. 101 and 114. For size, see Sec. 157.

78. A Drop Siding must be practically free from defects on the face side and well manufactured.

79. B Drop Siding will admit any two of the following defects or their equivalent of combined defects: Slight torn grain; three pin knots; one standard knot; 15 per cent. sap stain; 15 per cent. firm red heart; small seasoning checks; 6 pin wormholes; or any one of the above defects, combined with one of the following: Three small pitch pockets or one small pitch streak.

80. No. 1 Common Drop Siding will admit one standard pitch streak or one standard pitch pocket, or their equivalent; and, in addition, sound knots not over one-half the width of piece in the rough; sap stain; firm red heart; slight shake; heavy torn grain; defects in manufacture that will lay without waste; seasoning checks; a limited number of pin wormholes well scattered.

Pieces otherwise as good as B may have one defect (like a knot hole) that can be cut out by wasting 1½ inches of the length of the piece, provided both pieces are 16 inches or over in length after cutting out such defects.

81. No. 2 Common Drop Siding admits of all pieces not as good as No. 1 Common that can be used without waste of more than one-fourth the length of any one piece.

Bevel Siding.

82. *Sizes.*—To be made from stock S4S worked to $\frac{13}{16}$ by 3½ and 5½ and resawed on a bevel.

83. *Lengths.*—Standard lengths 10 to 20 feet. Five per cent. of 8 or 9 feet is allowed in mixed length shipments of B and better Bevel Siding, and in addition 5 per cent. of 6 or 7 feet in No. 1 Common; and in addition 5 per cent. of 4 or 5 feet in No. 2 Common.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of feet of each length in such shipment be specifically stated.

84. *Grades.*—A, B, No. 1 and No. 2 Common.

85. Bevel Siding shall be graded according to the rules for Drop Siding, and will admit in addition slight imperfections on the thin edge, which will be covered by the lap when laid 2½ and 4½ inches to the weather.

Partition.

86. *Sizes.*—Partition shall be worked to ¾ by 3¼ and 5¼ inches.

87. *Lengths.*—Same percentage of short lengths allowed as in Ceiling.

88. *Grades.*—A, B, No. 1 and No. 2 Common.

89. Partition shall be graded according to Ceiling rules, and must meet the requirements of the specified grades on the face side only, but the reverse side shall not be more than one grade lower and shall not cause waste in No. 1 Common and better.

Molded Casing and Base Window and Door Jambs.

90. *Sizes of Molded Casing and Base.*—Shall be worked to ¾-inch as per pattern shown in Yellow Pine Manufacturers' Association Molding Book, 1908 edition. For Widths of Plain Casing, see Finishing, S4S.

91. *Window and Door Jambs.*—Dressed, Rabbeted and Plowed as ordered.

92. *Grades.*—A, B and C.

93. A Molding Casing and Base must be practically free from defects on the face side and well manufactured.

94. B Casing or Base shall admit the same defects as are admissible in the same widths of B Finishing, except wane.

95. C Casing or Base shall admit the same defects as are admissible in the same widths of C Finishing, except wane.

96. Window and Door Jambs shall be graded the same as Molded Casing and Base.

97. *B and Better Moldings.*—One-third of any item may contain any one of the following defects or its equivalent; one pin knot; small pitch pocket; pitch 1 inch wide, 6 inches long; slight sap stain covering 6 inches of the length of the piece; three pin wormholes; slight defects in dressing. Standard lengths 8 feet and longer, and in shipments of mixed lengths, 5 per cent. of 6 or 7 feet shall be admitted, even though the number of feet of each length in such shipment be specifically stated.

Sizes as per Yellow Pine Manufacturers' Association Molding Book, 1908 edition.

Common Boards, Shiplap and Barn Siding.

98. *Sizes of Boards.*—1 inch S1S or 2S to 13/16, 1¼ inch S1S or 2S to 1 1/16, 1½ inch S1S or 2S to 1 5/16.

99. *Widths.*—On stock width shipments of No. 1 Common, either rough or dressed one or two sides, no piece should be counted as standard width that is more than ¼-inch scant on 8 inches and under; ⅜-inch scant on 9 or 10 inches, or ½-inch scant on 11 or 12 inches or wider. Pieces narrower than this should be measured as if of the next lower standard in width and not reduced in grades. Material worked two faces to serve two purposes, liked grooved roofing S2S, shiplap S2S, center matched S2S or one face worked to a pattern, like barn siding, shall be inspected from the best face. 1¼-inch and 1½-inch common shall take the same inspection as 1-inch boards.

Boards S1S 1 by 8 S4S shall be worked 7½ inches wide; 1 by 9—8½ inches; 1 by 10—9½ inches; 1 by 11—10½ inches; 1 by 12—11¼ inches.

100. Sizes of No. 1 Common Shiplap or D&M and Barn Siding, 8, 10 and 12 inches shall be worked to 13/16 by 7⅛, 9⅛ and 11⅛ inches.

101. *Grades.*—No. 1, No. 2, No. 3 and No. 4 Common.

102. No. 1 Common Boards, dressed one or two sides, will admit any number of sound knots, and the mean or average diameter of the knots shall not be more than one-fourth of the cross-section if located on the edge, and shall not be more than one-third of the cross-section if located away from the edge; two pith knots; one split not to exceed in length the width of the piece; torn grain; pitch, pitch pockets; slight shake; sap stain; seasoning checks; firm red heart; wane ½-inch deep on edge, not exceeding 1½ inches wide and one-third of the length of the piece or its equivalent, and a limited number of pin wormholes well scattered, or defects equivalent to the above.

103. No. 1 Common Shiplap or D&M and Barn Siding shall be graded by rules governing No. 1 Common Boards, except as to wane, which shall not be so deep as to extend into the tongue, or one-half the thickness of the top lip on the groove in D&M, or over one-half the thickness of the lap in Shiplap on the face side.

Grooved Roofing.

104. *Size of Grooved Roofing.*—10 and 12 inches S1S and 2E shall be worked to 13/16 by 9½ and 11¼.

105. *Size of Groove.*—½-inch wide, ¼-inch deep and located 1 3/16 inches from outer edge of the groove to edge of board.

106. Grooved roofing shall be graded by rules governing No. 1 Common Boards, omitting the pith knots, wormholes and splits.

No. 2 Common Boards, Shiplap, Grooved Roofing and Barn Siding.

107. *Sizes.*—1 inch S1S or 2S to 13/16, 1¼ inches S1S or 2S to 1 1/16, 1½ inches S1S or 2S to 1 5/16.

108. *Widths.*—On stock width shipments of No. 2 Common, either rough or dressed one or two sides, no piece should be counted as standard width that is more than ½-inch scant on 8 inches and under ⅝ on 9 or 10 inches, and ¾-inch on 11 and 12 inches or wider. Pieces narrower than this should be measured as the next lower standard in width and not reduced in grades.

109. No. 2 Common Boards, dressed one or two sides, No. 2 Common Shiplap, Grooved Roofing, D&M and Barn Siding, will admit knots not necessarily sound, and the mean or average diameter of the knots shall not be more than one-third of the cross-section if located on the edge, and shall not be more than one-half of the cross-section if located away from the edge; if sound, may extend one-half the cross-section if located on the edge; wormholes; splits one-fourth the length of the piece; through rotten streaks one-fourth the length of the piece, or its equivalent of unsound red heart; through heart shakes, or wane 2 inches wide, one-half the length of the piece, or defects equivalent to the above.

A knot hole 3 inches in diameter will be admitted, provided piece is otherwise as good as No. 1 Common.

110. No. 3 Common Boards, No. 3 Common Shiplap, D&M and Barn Siding is defective lumber, and will admit of coarse knots, knot holes, very wormy pieces, red rot and other defects that will not prevent its use as a whole for cheap sheathing, or cutting three-fourths its length as No. 2 Common.

111. No. 4 Boards shall include all pieces that fall below the grade of No. 3 Common. It is the lowest recognized grade and it is offered on its merits as defective lumber.

112. Miscut 1 inch Common Boards which do not fall below ¾-inch in thickness shall be admitted in No. 2 Common, provided the grade of such thin stock is otherwise as good as No. 1 Common.

Fencing. 3, 4, 5 and 6 Inches Wide.

113. *Sizes.*—1 inch S1S or 2S to 13/16, 1¼ inch S1S or 2S to 1 1/16, 1½ inches S1S or 2S to 1 5/16.

114. *Widths.*—On stock width shipments of 3, 4, 5 and 6 inch No. 1 Common, no piece should be counted as standard width that is more than ¼-inch scant in width. Pieces narrower than this should be measured as of the next lower standard in width and not reduced in grades.

115. *Grades.*—No. 1, No. 2, No. 3 and No. 4 Common.

116. No. 1 Fencing will admit the following defects or their equivalent: Sound knots, the mean or average diameter of which shall not be more than one-half the cross-section of the piece at any point throughout its length; three pith knots; wane one-half inch deep on edge not exceeding 1½ inches wide and one-half of the length of the piece; torn grain; pitch; pitch pockets; sap stain; seasoning checks; slight shake; firm red heart and a limited number of small wormholes, well scattered.

No. 2 Fencing.

117. *Sizes.*—One (1) inch, S1S or 2S to $\frac{13}{16}$-inch.

118. *Widths.*—3, 4, 5 and 6 inch No. 2 Common stock, no piece shall be counted as standard width that is more than ½-inch scant in width. Such pieces should be measured as of the next lower standard of width and not reduced in grade.

119. No. 2 Fencing, in addition to the defects allowed in No. 1 Common, will admit the following defects or their equivalent: Knots, not necessarily sound, the mean or average diameter of which shall not be more than one-half the cross-section if located on the edge, and shall not be more than two-thirds of the cross-sectiton if located away from the edge; one split one-fourth the length of the piece; wormholes, through rotten streak one-fourth the length of the piece, shake or wane, but must not cut to waste.

A knot hole 1½ inches in diameter or its equivalent in small hollow knots will be allowed, provided the piece is otherwise as good as No. 1 Common.

120. No. 3 Fencing is defective lumber, and will admit of coarse knots, knot holes, very wormy pieces, red rot and other defects that will not prevent its use as a whole for cheap sheathing, or cutting three-fourths its length as No. 2 Common.

121. No. 4 Fencing shall include all pieces that fall below the grade of No. 3 Common. It is the lowest recognized grade, and it is offered on its merits as defective lumber.

122. Miscut 1 inch Common Fencing which does not fall below ¾-inch in thickness shall be admitted in No. 2 Common, provided the grade of such thin stock is otherwise as good as No. 1 Common.

Dimension and Heavy Joist.

123. *Sizes.*—Dimension shall be worked to the following: 2 by 4 S1S and 1E to 1⅝ by 3⅝ inches; 2 by 6 S1S and 1E to 1⅝ by 5⅝ inches; 2 by 8 S1S and 1E to 1⅝ by 7½ inches; 2 by 10 S1S and 1E to 1⅝ by 9½ inches; 2 by 12 S1S and 1E to 1⅝ by 11½ inches. Dimensions S4S ⅛-inch less in thickness and width than S1S1E shall be standard, but no objection shall be made to stock finished to the standard size for S&E.

124. *Heavy Joists.*—Shall be worked to the following: 2 by 14, 2½ and 3 by 10, 3 by 12 and 3 by 14, S1S and 1E, green, ¼-inch off side and ½-inch off edge. S4S ¼-inch off each face surfaced. Heavy Joists, rough, green, must not be over ¼-inch scant in width or thickness.

Dry 2 by 14 shall be dressed to the standard thickness of 2 by 12.

125. *Grades.*—No. 1, No. 2 and No. 3 Common.

126. Inspection of Dimension is a question of strength and uniformity of size and whatever reduces its strength in cross-section must be considered a defect to that extent. In computing the area of cross-section occupied by defects the size of the piece in the rough shall be considered.

127. No. 1 Common Dimension and Heavy Joists will admit sound knots, none of which in 2 by 4s should be larger than 2 inches in diameter on one or both sides of the piece, and on wider stock which do not occupy more than one-third of the cross-section at any point throughout its length if located at the edge of the piece; or more than one-half of the cross-section if located away from the edge; pith knots, or smaller or more defective knots which do not weaken the piece more than the knot aforesaid, will admit of seasoning checks; firm red heart; heart shakes that do not go through; wane ¾-inch deep on edge, one-quarter the width and one-third the length of the piece; pitch; sap stains; pitch pockets; splits in ends not exceeding in length the width of the piece; a limited number of small wormholes well scattered, and such other defects as do not prevent its use as substantial structural material.

128. No. 2 Common Dimension may have knots not necessarily sound, which do not occupy more than one-half of the cross-section at any one point if located at the edge of the piece, nor more than two-thirds of the cross-section if located away from the edge; smaller, loose, aforesaid, will admit rotten streaks; shake; wane; wormholes; split hollow or rotten knots that do not weaken the piece more than the knots not to exceed one-quarter the length of the piece, and other defects which do not prevent its use without waste.

129. No. 3 Dimension will include all pieces falling below No. 2 grade which are sound enough to use for cheap building material, by wasting 25 per cent. of each piece of one-third of number of pieces in any item of a shipment, but it must not be more than ½-inch scant of standard finished width or ⅜-inch scant in thickness.

130. Miscut 2 inch Common stock which does not fall below 1½ inches in thickness or ⅛-inch scant in width from standard size, shall be admitted in No. 2 Common, provided such pieces are in all other respects as good as No. 1 Common.

Rough Yellow Pine Finishing.

131. *Widths.*—On stock width shipments of C and better finish, either rough or dressed one or two sides, no piece should be counted as standard width that is more than ¼-inch scant on 8 inches and under; ⅜-inch scant on 9 and 10 inches, or ½-inch scant on 11 and 12 inches or wider. Such pieces should be measured as the next lower standard of width, and not reduced in grade.

132. *Lengths.*—Standard Lengths are 10 to 20 feet, and in shipments of mixed lengths 5 per cent. of 8 or 9 feet in grades of C and better shall be admitted.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of feet of each length in such shipment be specifically stated.

133. Finish must be evenly manufactured, and shall embrace all sizes from 1 to 2 inches in thickness by 3 inches and over in width.

134. One inch, 1¼ and 1½ finishing lumber, unless otherwise ordered, shall measure when dry more than $\frac{1}{16}$-inch scant in thickness; on 2-inch it may be ⅛-inch scant.

135. Wane and seasoning checks and other defects that will dress out in working to standard thickness and widths are admissible.

136. Subject to the foregoing provisions, Rough Finishing shall be graded according to the specifications applying to dressed finishing lumber.

137. Finishing lumber ordered rough, if thicker than the count thickness for dry or green stock, may be dressed to such count thickness and when so dressed shall be considered as rough.

When like grade on both faces is required, special contract must be made.

Common Boards, Fencing and Dimension.

138. Rough Common Boards and Fencing should not be less than ⅞-inch thick when dry.

139. Rough 2 inch Common should not be less than 1⅞ inches thick when green, or 1¾ inches thick when dry. The several widths should not be less than ⅛-inch over the standard dressing width for such stock when dry.

140. Rough Common Dimension of a greater thickness than 2 inches and less than 4 inches shall be subject to special contract as to thickness and width.

141. Rough Dimension, if thicker than specified thickness for dry or green stock, may be dressed to such standard thickness, and when so dressed shall be considered as rough stock.

142. The defects admissible in Rough Boards, Fencing and Dimension shall be the same as those applying to dressed stock of like kind and grade, and such further defects as would disappear in dressing to standard sizes of such material shall be allowed.

No. 1 Common Timbers. (Not to include bridge and trestle timbers.)

148. No. 2 shall consist of pieces that fall below the grade of No. 1 4 by 4, 4 by 6, 6 by 6, ⅜-inch off side and edge. Surfaced four sides, ¼-inch off each side, 6 by 8 and larger S3S or S4S, ¼-inch off each side surfaced.

144. Rough Timbers, 4 by 4 and larger, shall not be more than ¼-inch scant at any point when green, and be well manufactured, with not less than three square edges, and will admit sound knots that do not occupy more than one-third the cross-section of the piece or small defective knots.

Timbers 10 by 10 in size may have a 2-inch wane on one corner, measured on faces, or its equivalent on two or more corners one-third the length of the piece. Larger sizes may have proportionately greater defects.

Shakes extending not over one-eighth the length of the piece are admissible, and seasoning checks shall not be considered a defect.

145. Dressed Timbers shall conform in grading to the specifications applying to rough timbers of same size.

146. Rough Timbers, if thicker than specified thickness for dry or green stock, may be dressed to such standard thickness, and when so dressed shall be considered as rough stock.

147. *Yellow Pine Plastering Lath.*—No. 1 should measure 2 inches in thickness to every five lath, green, the minimum thickness of any one lath shall not be less than 5/16-inch, green, and should not be less than 1 7/16 inches in width, green, length 4 feet, 1⅝ inches thickness to every

five lath, dry, and should not measure less than 1 5/16 inches in width, dry. Will admit wane ⅛-inch deep, ¼-inch on face, and 6 inches long, pin wormholes and one pin knot. Must not be more than ½-inch scant in length. Blue sap stain shall not be considered a defect.

148. No 2 shall consist of pieces that fall below the grade of No. 1 which are not less than 1¼ inches in width, ¼-inch thick, when dry, and are not more than ¾-inch short in length. Will admit wane; wormholes; knots and other defects that will not prevent their use the entire length without waste.

Byrkit Lath.

149. *Sizes.*—¾ by 3½ and 5¼ inches wide, lengths 4 feet and upward.

150. Standard Byrkit Lath shall consist of material that will be held firmly in place and support plaster by ordinary nailing by not wasting more than 10 per cent. of any piece, and that will present a full surface with no openings over ½-inch in width and 3 inches in length. The ends of pieces of Byrkit Lath are not expected to meet on studding, and only such quantity shall be counted waste as is necessary to remove a defect.

Standard Sizes of Dressed Lumber.

151. Finishing shall be dressed to the following: 1 inch S1S or 2S to 13/16; 1¼ inches S1S or 2S to 1 1/16; 1½ inches S1S or 2S to 1 5/16; 2 inches S1S or 2S to 1¾ inches. 1 by 4 S4S shall be 3½ inches wide finished; 1 by 5 S4S shall be 4½ inches wide; 1 by 6—5½ inches; 1 by 7—6½ inches; 1 by 8—7½ inches; 1 by 9—8½ inches; 1 by 10—9½ inches; 1 by 11—10½ inches; 1 by 12—11¼ inches.

The foregoing width shall also apply to stock thicker than 1 inch.

152. *Molded Casing and Base.*—Shall be worked to ¾-inch as per pattern shown in Yellow Pine Manufacturers' Association Molding Book, 1908 edition.

153. *Flooring.*—The standard of 1 by 3, 1 by 4 and 1 by 6 inches D and better shall be worked to 13/16 by 2¼, 3¼ and 5¼ inches; 1¼-inch Flooring shall be 1 3/32 inches thick; 1½ inch Flooring to 1 11/32 inches thick, the same width and matching as 1 inch stock.

154. *Drop Siding.*—D&M shall be worked to ¾ by 3¼ and 5¼ inch face, 3½ and 5½ over all. Worked Shiplap, ¾ by 3 inch face, 3½ inches over all, ¾ by 5 inch face, 5½ inches over all. Patterns that are not shown in Yellow Pine Manufacturers' Association Molding Book of January, 1908 edition are considered special.

155. Ceiling shall be worked to the following: $\frac{3}{8}$-inch Ceiling, $\frac{5}{16}$-inch; $\frac{1}{2}$-inch Ceiling, $\frac{7}{16}$-inch; $\frac{5}{8}$-inch Ceiling, $\frac{9}{16}$-inch; $\frac{3}{4}$-inch Ceiling, $\frac{11}{16}$-inch. Same width as Flooring. The standard working of Ceiling shall be beaded center and edge, with slight bevel on grooved edge. The bead on all Ceiling and Partition shall be depressed $\frac{1}{32}$-inch below surface line of piece.

156. Partition shall be worked to the following: $\frac{3}{4}$ by $3\frac{1}{4}$ and $5\frac{1}{4}$ inches. Same standard for location of and size of bead as applies to ceiling.

157. *Bevel Siding.*—To be made from stock S4S worked to $\frac{13}{16}$ by $3\frac{1}{2}$ and $5\frac{1}{2}$ and resawed on a bevel.

158. *Window and Door Jambs.*—Dressed, Rabbeted and Plowed as ordered.

159. *Boards and Fencing.*—1 inch S1S or 2S to $\frac{13}{16}$-inch.

160. Shiplap and Barn Siding No. 1 Common. 8, 10 and 12 inches shall be worked to $\frac{13}{16}$ by $7\frac{1}{8}$, $9\frac{1}{8}$ and $11\frac{1}{8}$ inches.

161. D&M No. 1 Common. 8, 10 and 12 inches shall be worked to the following. $\frac{13}{16}$ by $7\frac{1}{8}$, $9\frac{1}{8}$ and $11\frac{1}{8}$ inches.

162. *Grooved Roofing.*—10 and 12 inches S1S and 2E shall be worked to $\frac{13}{16}$ by $9\frac{1}{2}$ and $11\frac{1}{4}$.

163. Dimensions shall be worked to the following: 2 by 4 S1S and 1E to $1\frac{5}{8}$ by $3\frac{5}{8}$ inches; 2 by 6 S1S and 1E to $1\frac{5}{8}$ by $5\frac{5}{8}$ inches; 2 by 8 S1S and 1E to $1\frac{5}{8}$ by $7\frac{1}{2}$ inches; 2 by 10 S1S and 1E to $1\frac{5}{8}$ by $9\frac{1}{2}$ inches; 2 by 12 S1S and 1E to $1\frac{5}{8}$ by $11\frac{1}{2}$ inches. Dimension S4S $\frac{1}{8}$-inch less than standard size S1S and 1E.

164. Heavy Joists (not to include bridge and trestle timbers) shall be worked to the following: 2 by 14, $2\frac{1}{2}$ and 3 by 10, 12 and 14, S1S and 1E, green, $\frac{1}{4}$-inch off side and $\frac{1}{2}$-inch off edge. S4S $\frac{1}{4}$-inch off each face surfaced. Heavy Joists, rough, green, must not be over $\frac{1}{4}$-inch scant in width or thickness.

165. *Heavy Flooring.*—For 2 and $2\frac{1}{2}$-inch matching the thickness should be $\frac{3}{8}$-inch less than the rough material. The tongue should be $\frac{3}{8}$-inch thick and $\frac{3}{8}$-inch long. For 3 inches and thicker matching the tongue should be $\frac{3}{4}$-inch thick and $\frac{3}{8}$-inch long, and the thickness of the stock should be $\frac{3}{8}$-inch less than the rough material. The groove in heavy matchings should be $\frac{1}{16}$-inch wider than the thickness of the tongue, and $\frac{1}{16}$-inch deeper than the length of the tongue. Tongue and groove shall be located one-fourth the thickness of the rough material from the bottom of the piece. In 2 inches and thicker material plowed

for splines the groove should be the same width and depth as is provided for in matching material of the same thickness.

Heavy shiplap shall be worked to the same thickness as heavy flooring. The lap shall be $\frac{1}{2}$-inch long, occupying one-half the finished thickness of the piece.

Timbers shall be worked to the following: 4 by 4 and larger, S1S or S&E, $\frac{3}{8}$-inch off each face surfaced; S3S or S4S, $\frac{1}{4}$-inch off each face surfaced.

166. *Yellow Pine Plastering Lath.*—No. 1 should measure 2 inches in thickness to every five lath, green, the minimum thickness of any one lath shall not be less than $\frac{5}{16}$ of an inch green, and should not be less than $1\frac{7}{16}$ inch in width, green, length 4 feet; $1\frac{5}{8}$ inch thickness to every five lath, dry, and should not measure less than $1\frac{5}{16}$ inches in width, dry. Must not be more than $\frac{3}{4}$-inch short in length when dry.

167. No. 2 must not be less than $1\frac{1}{4}$ inches in width, $\frac{1}{4}$-inch thick, when dry, and not more than $\frac{3}{4}$-inch short in length.

168. *Byrkit Lath.*—$\frac{3}{4}$ by $3\frac{1}{2}$ and $5\frac{1}{4}$ inches wide, lengths 4 feet and upward.

Pickets.

169. *Square Pickets.*—From $1\frac{1}{2}$-inch stock shall be worked to $1\frac{5}{16}$ by $1\frac{5}{16}$, 3 and 4 feet long, dressed on four sides and pointed. From $1\frac{1}{4}$-inch stock shall be worked to $1\frac{1}{16}$ by $1\frac{1}{16}$, 3 and 4 feet long, dressed on four sides and pointed.

170. *Flat Pickets.*—From 1 by 3 stock shall be worked to $\frac{3}{4}$ by $2\frac{1}{4}$, 3 and 4 feet long, dressed on four sides and headed.

[3] SPECIFICATIONS FOR CONSTRUCTION OAK TIMBERS.

General Instructions.

Those who are not familiar with the anatomy of the oak tree should, when reading over these rules, take into consideration that the rule describes the poorest piece that goes into the grade and that a large per cent. is above the grade described.

Definition of Oak for Construction Purposes.

The term "Construction Oak" means all such products of oak in which the strength and durability of the timber is the controlling element in its selection and use. The following is a list of products which are recommended for consideration as "Construction Oak":

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[3] Adopted Vol. 12, Part 3, 1911, pp. 601-606; Vol. 13, 1912, pp. 874, 1053.

Firsts are to be sound and free from heart, shakes and checks, but may have other defect as follows:

Construction Oak.

Trestle and Bridge Timbers.—Mud Sills, Stringers, Caps, Posts, Bracing, Bridge Ties, Struts, Guard Rails, Girts, Sash and Sway Braces.

Docking and Platform Timbers.—Mud Sills, Posts, Bracing, Caps, Stringers, Joists, Dock and Platform or Flooring Plank and Wales.

Platform or Flooring Plank can be either square edged or matched.

Ties.—Switch Ties.

Framing for Building.—Mud Sills, Posts, Girders, Framing Joists, etc.

Bridge and Crossing Plank.—Railroad Crossing Plank, Bridge Floor Planking.

Sheet Piles.—Same as Crossing Plank, except may contain unlimited amount of heart.

Round Piling.

Stock Guards.

Track or Bumper Post.

Standard Defects.

Definition of "Defect".—Fault, blemish, mark of imperfection that will materially injure the strength.

Measurements which refer to the diameter of knots or holes shall be considered as referring to the mean or average diameter.

Knots.

A Sound Knot is one which is solid across its face, and which is as hard as the wood surrounding it; it may be any color and contain checks.

A Loose Knot is one not firmly held in place by growth or position.

A Pith Knot is a sound knot with a pith hole not more than ¼-inch in diameter in the center.

A Rotten Knot is one that is not sound and not as hard as the wood surrounding it.

A Pin Knot is a sound knot not over ¾-inch in diameter.

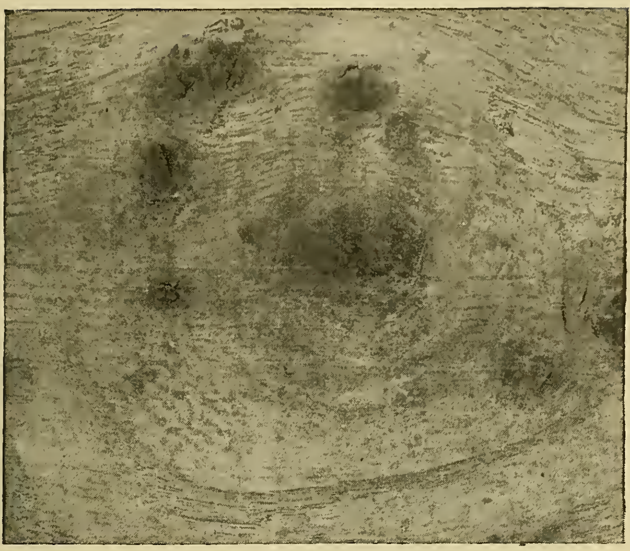
A Standard Knot is a knot over 2 inches in diameter.

A Large Knot is a sound knot more than 2 inches in diameter.

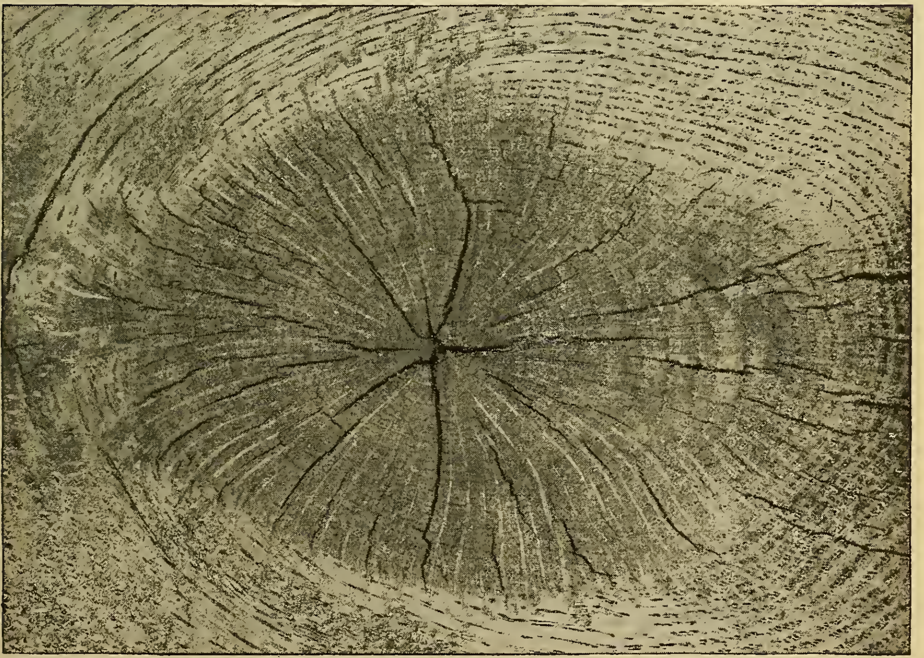
A Round Knot is one which is oval or circular in form.

A Spike Knot is one sawn in a lengthwise direction. The mean or average width shall be considered in measuring this knot.

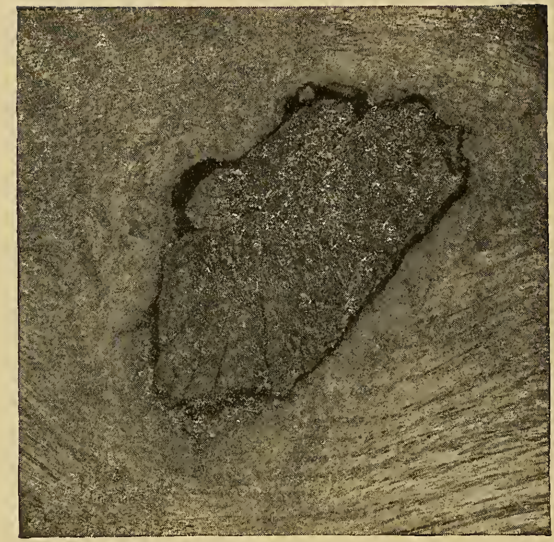
Bird Peck are bruises apparently caused by bird pecks during the growth process of the timber. Considered no defect.



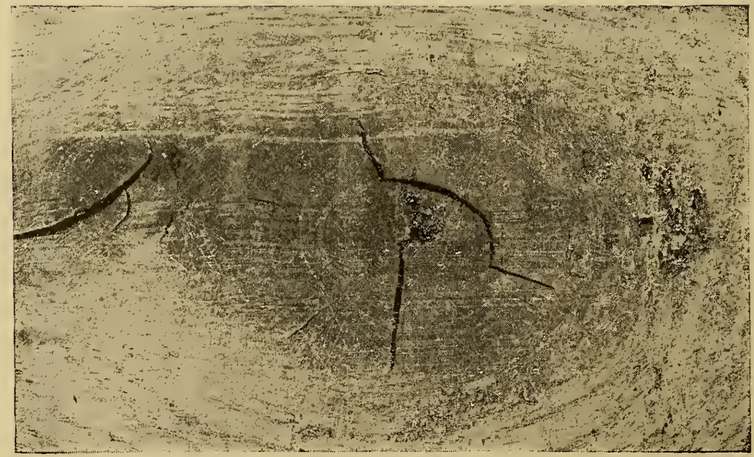
Sound Knot.



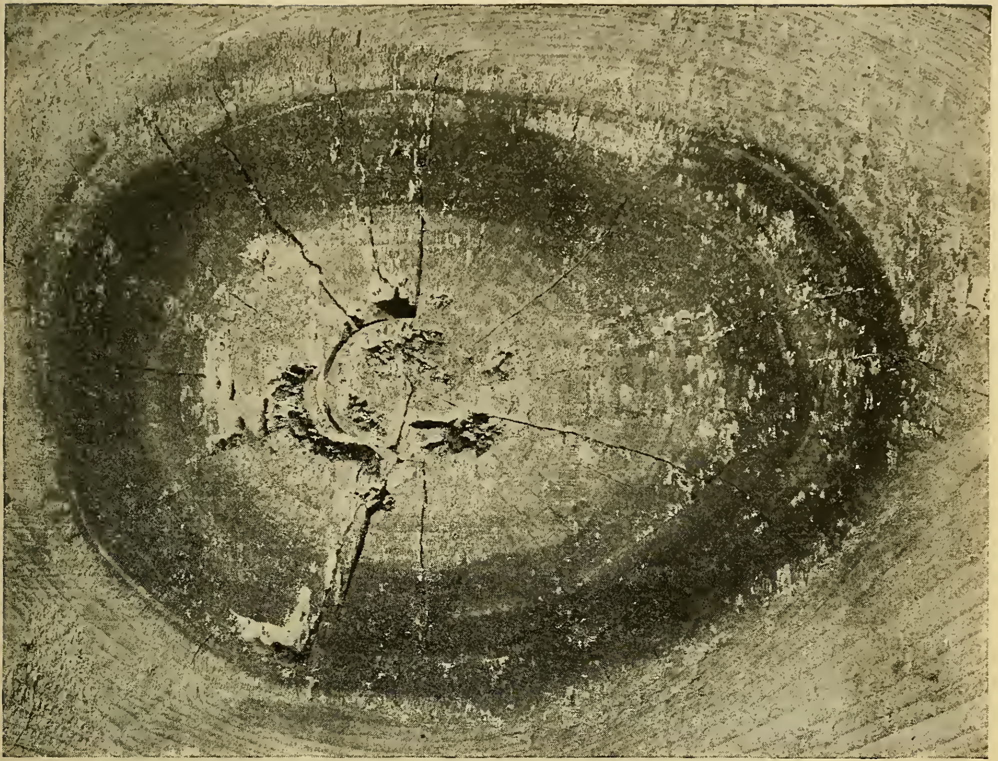
Large Knot.



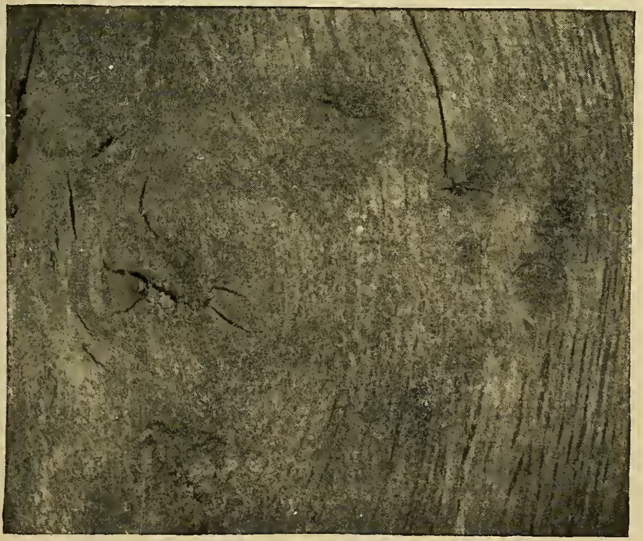
Loose Knot.



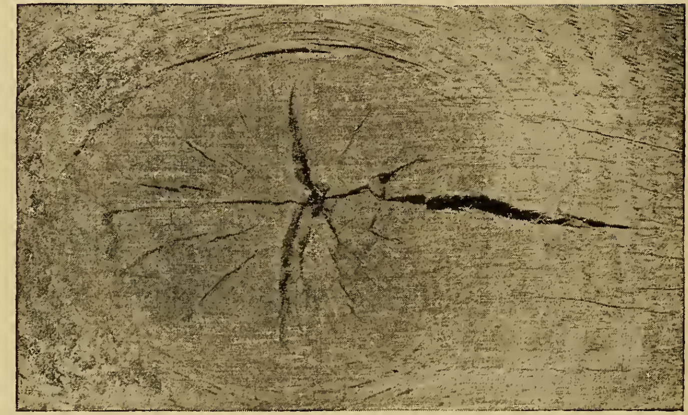
Pith Knot.



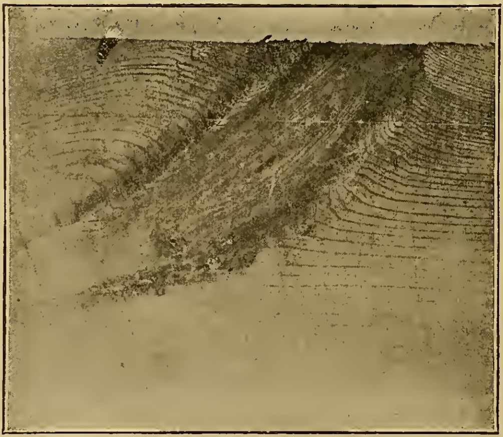
Rotten Knot.



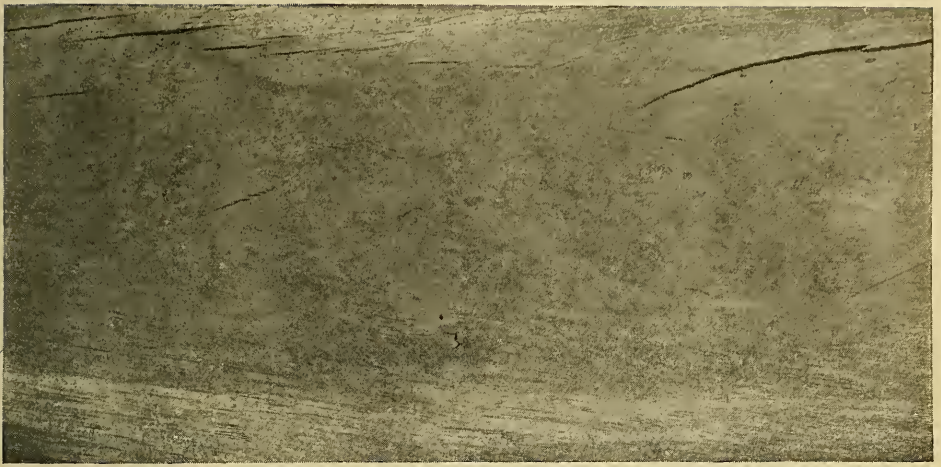
Pin Knot.



Standard Knot.

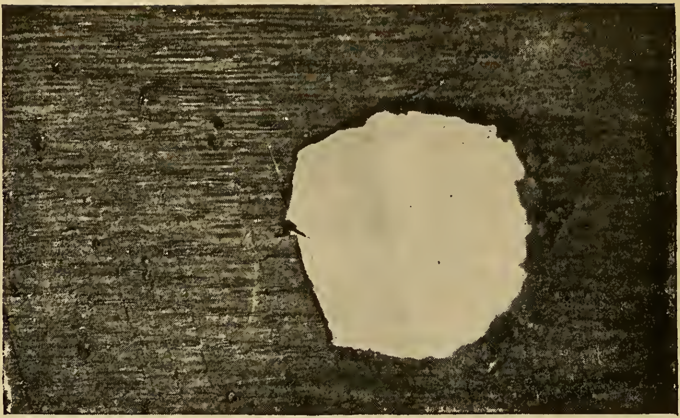


Spike Knot.



Burl Knot.

Pin Worm.



Wooden Rafting Pin Hole.

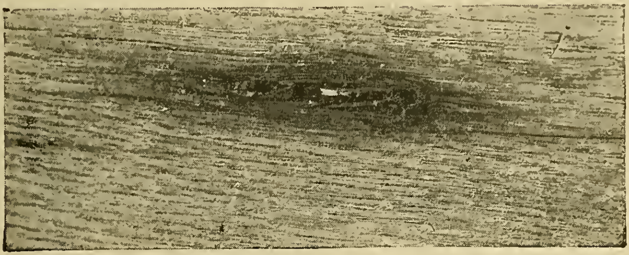
Worm Defects.

Pinworm Holes are very small holes caused by minute insects or worms. These holes usually are not over $\frac{1}{16}$-inch in diameter, or smaller, and the wood surrounding them is sound and does not show any evidence of the wormhole having any effect on the wood other than the opening.

Spotworm Defects (also known as Flagworm Defects) are caused, like Pinworm Holes, by minute insects or worms working on the timber during its growth. The size of the hole is about the same as Pinworm Holes, but the surrounding wood shows a colored spot as evidence of the defect. This spot is usually sound and does not affect the strength of the piece.

Spot Worm.

Grubworm Holes are usually from about 1/8-inch to 3/16-inch in width, and vary in length from about 1 inch to 1¼ inches or 1½ inches and are caused by grubs working in the wood.



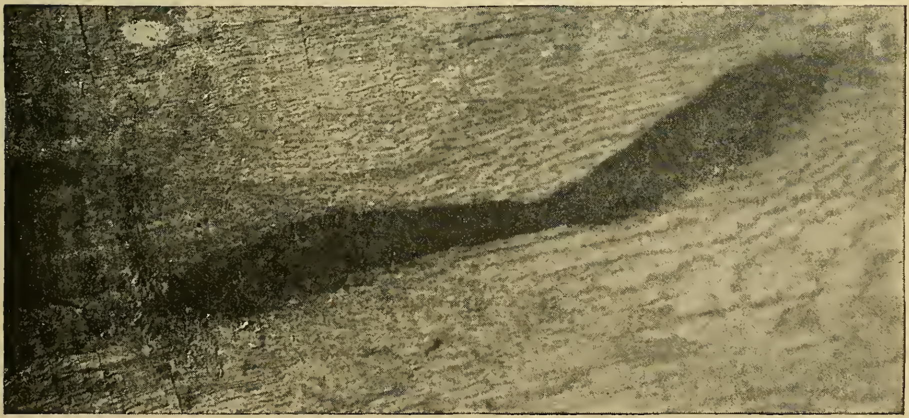
Metal Rafting Pin Hole.

Wooden Rafting Pinholes sometimes appear on river timber which has been rafted and holes bored in the solid wood for tying the timber, and a solid plug or pin driven in the hole, filling it completely. These defects must be treated and considered the same as Knot Defects. Ordinary Metal, Rafting Pin or Chain Doghole is considered no defect.

Sap.

"Sap" is the alburnum of a tree—the exterior part of the wood next to the bark. Sapwood is not considered a defect.

The term "Sound Heart" is used in these rules whenever heart of piece is split or opened and shows on outside of piece and its condition is sound and solid, not decayed. Openings between annual rings or checks not considered a defect.



Grub Worm Holes.

Wane.

Wane is bark or the lack of wood from any cause on edges of timber.

Shakes.

"Shakes" are splits or checks in the timber which usually cause a separation of the wood between the annual rings.

(1) Ring Shakes are openings between the annual rings, usually showing only on the end of timber.

(2) Through shakes are shakes which extend between two faces of the timber.

(3) *Checks.*—A small crack in the wood due to seasoning, not considered a defect.

Grain.

Crooked or Crossgrain.—Crooked or Crossgrain crosses the piece within a section 24 inches in running length of the piece. This is only considered a defect in certain smaller sizes of dimensions for specific purposes.

Rot.

Any form of decay which may be detected as giving the timber a doty or rotten texture is a rotten defect, including what is commonly known as dryrot. Water Stain, or what are sometimes called scalded or burnt spots, usually caused by timber lying in the water under certain conditions before it is sawed, and burnt spots where the timber is improperly piled green, not considered defects, as they do not affect the strength of the piece.

Standard Names for Construction Oak.

Unless specially mentioned, the terms White Oak and Red Oak include the following:

WHITE OAK.—
White Oak.
Chestnut or Tanbark Oak.
Burr or Mossy Cup Oak.
Rock Oak.
Post or Iron Oak.
Overcup Oak.
Live Oak.
Basket or Cow Oak.
Swamp Post Oak.
Yellow or Chinquapin Oak.

RED OAK.—
Red Oak.
Pin Oak.
Black Oak.
Water Oak.
Willow Oak.
Spanish Oak.
Turkey Oak.
Black Jack or Barn Oak.
Shingle or Laurel Oak.
Scarlet Oak.

Term.—Mixed Oak means any kind of Oak.

SPECIFICATIONS FOR STRUCTURAL OAK TIMBERS.

General Requirements.

(1) Except as noted, all Structural Timbers shall be White Oak, to be sound timber and sawed specified sizes; free from ring shakes, crooked grain, rotten knots, large knots in groups, rot, dote and wane in amounts greater than allowed in these specifications.

Boxed Hearts.

(2) Boxed Hearts are permitted in pieces of 5 by 5 square and larger. The center of the heart should be boxed as near the center of the piece as practical, and not to exceed 30 per cent. of the pieces can have the center of the heart nearer than 1½ inches from any face; 20 per cent. may show one heart face, corner or edge, not to exceed 75 per cent. of the length of the piece.

Wane.

The term 20 per cent. of number of pieces or amount shipped refers to each item and size of each car shipped.

(a) Pieces 5 by 5 to 8 by 8 square may show 1 inch wane, side measurement, on any two corners or edges, and this wane not to exceed more than 25 per cent. of the length of the piece singly, or 50 per cent. in aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 50 per cent. of the length of the piece as above described; not to exceed 20 per cent. of number of pieces may have this defect.

(b) Pieces over 8 by 8, including 12 by 12 square, may show 1½-inch wane, side measurement, edge of any two corners or edges, and this wane not to exceed more than 33⅓ per cent. of the length of the piece singly, or 66⅔ per cent. in aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 66⅔ per cent. of the length of the piece as above described; not to exceed 20 per cent. of number of pieces may have this defect.

(c) Pieces over 12 by 12 square may show 1¾-inch side measurement, any two corners of edges, and this wane not to extend more than 40 per cent. of the length of the piece singly, or 80 per cent. in aggregate, in the absence of wane on all corners, excepting one, the one corner may contain wane 80 per cent. of the length of the piece as above described; not to exceed 20 per cent. of number of pieces may have this defect.

(d) In event that pieces have two faces as wide as above described and two faces narrower, the proportion of the amount of wane is admissible.

(e) Pieces 1 inch to 5 inches thick, not exceeding 8 inches wide, are governed by defect specifications above mentioned, with the exception that they shall not contain wane, and not to exceed 20 per cent. of pieces 2 inches and thicker may show sound heart on one face; pieces under 2 inches thick must be free of heart. Pieces 8 inches and wider may contain wane as per paragraphs b and d.

(f) Rough sizes of Structural Timber shall not vary more than ¼-inch scane of specified size. Dressed sizes may be ½-inch scant after dressing.

Ties.

(1) *Switch Ties Sawed.*—Thickness cut to order; widths cut to order; lengths cut to order; unless noted to be White Oak. Must contain three sound solid sides. One face or one corner (not both) may show sound heart. Large sound knots, pin, spot, or an occasional grubworm hole not considered a defect. Sizes may vary ½-inch from specified sizes.

(2) Cross-ties, sawed, etc.

Bridge, Dock, Crossing Plank.

Lengths, cut to order.
Widths, cut to order.
Thickness, cut to order.

Sizes cut to order, probably 2 inches, 3 inches and 4 inches thick, 6 inches, 8 inches, 10 inches and 12 inches wide, 12 feet, 14 feet and 16 feet long.

This product is intended to work full one good sound face, and this face side must be square edge. Sound knots, small pin and spot-worm holes no defect on face side.

Must be free from rot and shake; practically square edges, admitting 1 inch of wane on each edge of reverse face, running twô-thirds the length. Sound hearts on one side, rafting pinholes, knotholes or grubholes not exceeding 2 inches in diameter admitted.

Sheet Piles.

Same as for Ties, except that it may contain sound heart or heart check.

Stock Guards.

To be governed by specifications for Construction Oak.

Track End or Bumping Posts.

To be governed by specifications for Structural Timbers.

[1] CLASSIFICATION AND GRADING RULES FOR CYPRESS LUMBER AND SHINGLES.

General Instructions.

Cypress lumber shall be graded according to the following rules and specifications, bearing in mind that as no arbitrary set of rules and specifications can be maintained in every case, much must be left to the common-sense and best judgment of the inspector:

1. Lumber shall be manufactured and shipped in standard lengths and thicknesses.

2. Tank, 1st and 2d and worked partition shall be graded from the poorer side.

3. Select lumber, flooring, ceiling, bevel siding and finishing shall be graded from the better or finished side, but the reverse side should in no case be more than one grade lower.

4. All lumber shall be tallied surface or face measure, the tally counted up, and the one-quarter or one-half added to the total where the lumber is one and one-quarter or one and one-half inches thick, and 2 inches and thicker to be multiplied by the thickness.

5. In the measurement of all lumber, fractions exactly on the one-half foot are to be given alternately to the buyer and the seller; the fractions below the one-half foot are to be dropped, and all fractions above the one-half foot are to be counted to the next higher figure on the board rule.

6. In "line boards," pieces 14 feet and longer shall be given the advantage in grade; pieces 12 feet and shorter shall be reduced in grade.

7. Recognized defects in cypress are knots, knot holes, shake, splits, wane, wormholes, stained sap and peck.

Standard Defects.

8. A standard knot is sound and not to exceed 1¼ inches in diameter.

9. A small sound knot is one not exceeding ¾-inch in diameter.

10. Two small knots not to exceed in extent or damage one 1¼-inch knot.

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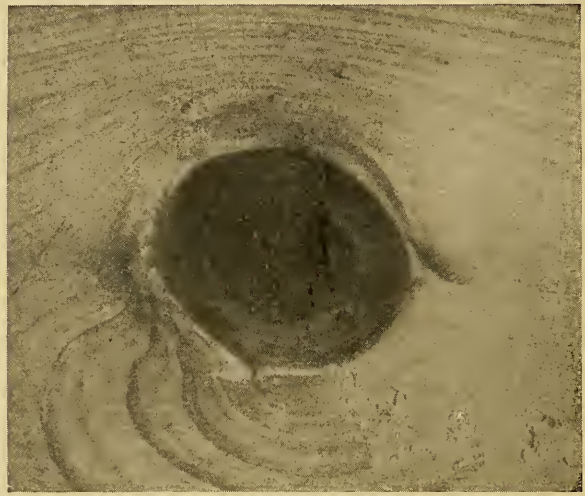
[1] Adopted, Vol. 13, 1912, pp. 873-884; Vol. 14, 1913, pp. 955, 956, 1101.

11. One straight split not to exceed in length the width of the piece.

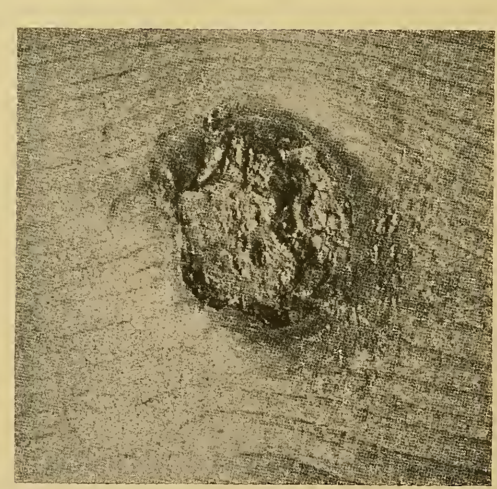
12. Worm, grub, knot and rafting pin holes not exceeding in damage one 1¼-inch knot.

13. Ordinary season checks shall not be considered a defect in any grade.

14. Ordinary season checks are such as occur in lumber properly covered on yard, or season checks of equal size in kiln-dried lumber.



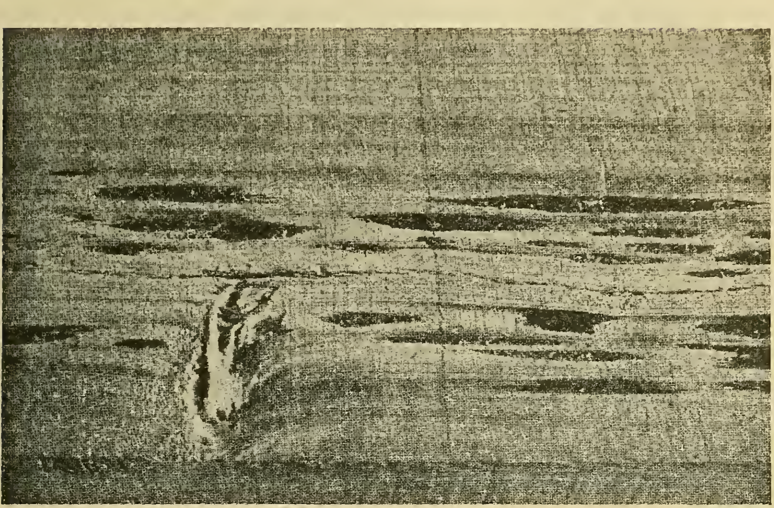
Standard Sound Knot.



Rotten Knot.

15. Bright sap is not a defect in select or below.

16. Pin wormholes, sound knots and stained sap shall not be considered a defect in No. 1 barn or below.



Pecky Cypress.

Standard Lengths.

17. Random standard length stock may be furnished in odd as well as even foot lengths, but there shall not be to exceed 20 per cent. of odd lengths in any one item.

18. Tank stock and No. 1 barn shall be 8 feet and longer.

19. 1st and 2d and select shall be 10 to 20 feet.

20. Finish, flooring, ceiling, partition, bevel and drop siding shall be 10 to 20 feet.

21. Moldings and battens of all sizes 6 to 20 feet, in both odd and even foot lengths, but not exceeding 10 per cent. of 6, 7, 8 and 9 foot lengths.

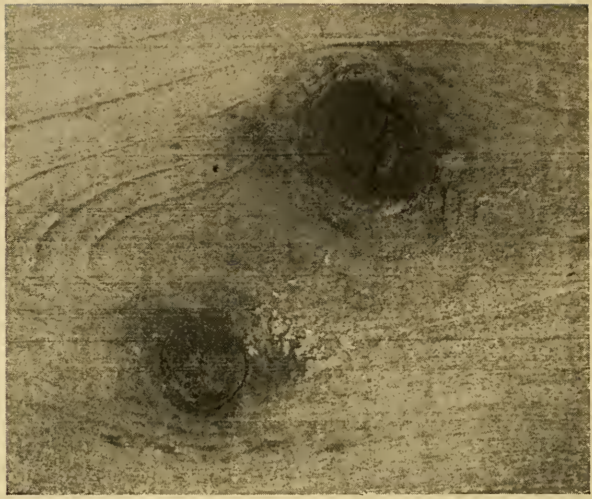
22. No. 2 barn, 6 feet and longer.

23. Cull or peck, 4 feet and longer.

Standard Finished Sizes of Cypress.

24. Lumber shipped in the rough (except 8/4 inch No. 1 and No. 2 "Dimension," which grades may be $\frac{1}{4}$-inch under or $\frac{1}{4}$-inch over the size specified, both in thickness and width) shall be of sufficient thickness to S2S to standard thickness, as follows:

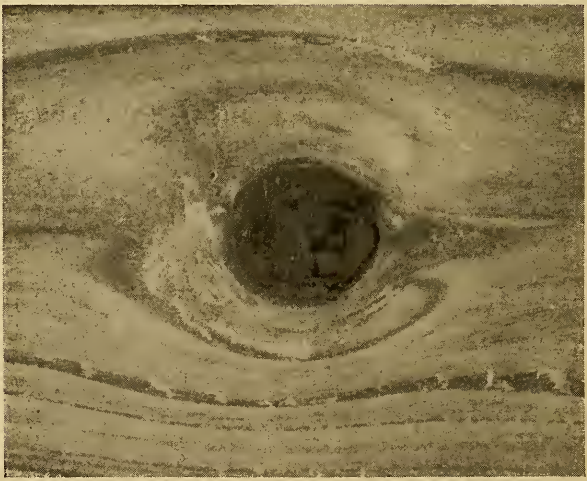
25. 4/4 lumber S1S or S2S shall be $\frac{13}{16}$-inch thick.



Two Small Knots Equal to One Standard Knot.

26. 5/4 select, 1st and 2d clear, selected common tank and tank lumber S1S or S2S, shall be 1⅛ inches thick.

27. 5/4 peck, No. 1 and No. 2 barn and finishing lumber S1S or S2S, shall be $1\frac{1}{16}$ inches thick.



Small Sound Knot.

28. 6/4 select 1st and 2d clear, selected common tank and tank lumber S1S or S2S, shall be 1⅜ inches thick.

29. 6/4 peck, No. 1 and No. 2 barn and finishing lumber S1S or S2S, shall be $1\frac{5}{16}$ inches thick.

30. 8/4 lumber, except No. 1 and No. 2 barn or dimension S1S or S2S, shall be 1¾ inches thick.

31. 8/4 No. 1 and No. 2 barn or dimension S1S or S2S shall be 1⅝ inches thick.

32. 10/4 lumber S1S or S2S shall be 2¼ inches thick.

33. 12/4 lumber S1S or S2S shall be 2¾ inches thick.

34. All lumber S1E takes off ⅜-inch. S2E, ½-inch.

35. All flooring shall be S2S and CM.

36. 4/4 flooring shall be $\frac{13}{16}$-inch by 2¼-inch, 3¼-inch, 4¼-inch, 5¼-inch face.

37. 5/4 flooring shall be $1\frac{1}{16}$, 6/4 shall be $1\frac{5}{16}$, by same widths as 4/4.

38. ⅜ ceiling shall be worked $\frac{5}{16}$-inch, S1S only.

39. ½ ceiling shall be worked $\frac{7}{16}$-inch, S1S only.

40. ⅝ ceiling shall be worked $\frac{9}{16}$-inch, S1S only.

41. ¾ ceiling shall be worked $\frac{11}{16}$-inch, S1S only.

42. Widths of ceiling to be the same as flooring, unless otherwise specified. Ceiling up to ¾-inch face to have one bead on one edge and ceiling wider than 3¼-inch face to be beaded center and edge.

43. Partition to be finished the same as ceiling, but on both faces.

44. Drop siding shall be worked ¾-inch by 3¼-inch, 4¼-inch, 5¼-inch, 7¼-inch, 9¼-inch face, S2S and CM or shiplapped.

45. Bevel siding or bevel cribbing shall be worked ½-inch less in width than the rough strip measure.

Tank Stock.

46. Shall be random widths, and will not be furnished in specified widths, and shall be graded from the poorer side.

47. Shall be 5 inches and wider, 1½ inches to 4 inches thick and 8 feet and over in length. Pieces up to 7 inches shall be free from sap. Pieces 7 inches to 13 inches may have 1 inch of sound sap on one edge, not to exceed half the length and half the thickness of the piece. Pieces 14 inches and wider may have 1 inch of sound sap on both edges not to exceed half the length and half the thickness of the piece. In all widths sound knots that do not impair usefulness for tank purposes may be admitted.

First and Second Clear.

48. Shall be random widths, and will not be furnished in specified widths, and shall be graded from the poorer side.

49. Shall be 8 inches and wider, 1 inch to 4 inches thick and 10 feet and over in length. Pieces 8 inches to 10 inches may have 1 inch of bright sap on each edge, or its equivalent on one or both edges, otherwise they must be clear. Pieces 10 inches and under 12 inches may have 1½ inches of bright sap on each edge or 3 inches on one edge; and may have one standard knot or its equivalent. Pieces 12 inches wide may have 2 inches of bright sap on each edge, or 4 inches on one edge and may have one standard knot; or, in lieu of sap, may have two standard knots or their equivalent. Pieces wider than 12 inches may admit of defects as specified above in proportion as width increases. Pieces 10 inches and wider may admit of one end split, which shall not exceed in length the width of the piece. Pieces 12 inches and less in width, free from other defects, may have bright sap across one face at one end, but this sap shall not exceed in length one-tenth of the length of the piece. In pieces 13 inches and wider bright sap is not a defect.

Selects.

50. Shall be random widths, and will not be furnished in specified widths, and shall be graded from the better side, but the reverse side shall not be of a lower grade than No. 1 shop or No. 1 barn.

51. Shall be 7 inches and wider, but will not be furnished wider than 12 inches; shall be 1 inch to 4 inches thick, 10 feet and longer. Pieces 10 inches and under in width shall admit two standard knots or their equivalent and an additional standard knot or its equivalent for every 2 inches in width over 10 inches. Pieces free from other defects, 10 inches and over in width, to admit pin wormholes on one edge one-tenth the width of the piece. Bright sap is not a defect in this grade. Slight wane on pieces 10 inches and over in width is allowed on one edge not over 3 feet in length. When no other defect appears, slight amount of stained sap may be allowed. Pieces 10 inches and wider may admit of one end split, which shall not exceed in length the width of the piece.

Selected Common Tank Stock.

52. Shall be 4 inches wide, or wider, 1½ inches and 2 inches thick, 8 feet and over in length. Sound sap no defect in this grade, but must be free from unsound knots or other defects that extend through the thickness of the piece, and must be square edged to work the full length of the piece.

No. 1 Barn or Dimension.

53. Shall be specified widths only, shall be 3 inches and wider, 1 inch and thicker, 8 feet and over in length, admitting sap, bright or stained, shake, season checks, knots, pin wormholes, a small amount of peck on one side and one edge, or very slight peck on both sides and both edges of pieces comparatively free from coarse defects; which defects, however, shall not be sufficient to seriously impair the strength, or prevent the use of each piece for "common" purposes in its full length and full width.

No. 2 Barn or Dimension.

54. Shall be specified widths, 3 inches and wider, 1 inch and thicker, 6 feet and over in length, admitting all the defects allowed in No. 1 barn, but same may be larger and coarser, and in addition will admit peck on both sides; however, the defects shall not be sufficient to prevent the use of each piece in full length and full width for low-grade fencing and other very common purposes.

Cull or Peck.

55. May be random or specified widths 3 inches and wider, 1 inch to 4 inches thick, 4 feet and over in length. Shall admit all pieces below the grade of No. 2 boxing, and shall also admit the product of that part of the log known as "pecky"; however, each piece shall have sufficient strength and nailing surface to permit its use as a low-grade boxing, crating, sheating and foundation material.

Finishing.

56. Shall be specified widths 4 inches and wider, 1 inch to 2 inches thick, 10 feet and over in length, and shall be graded from the better side, A, B and C, but the reverse side should not be more than one grade lower. All grades of finish, rough or S1S or S2S may vary ¼-inch from the width specified.

57. *"A" Finish.*—Pieces 4 inches and 5 inches wide shall be clear of sap, knots and other defects. Pieces 6 inches wide may have 1 inch of bright sap, or in lieu of sap one small sound knot. Pieces 7 inches and 8 inches wide may have 2 inches of bright sap, or in lieu of sap one small sound knot. Pieces 9 inches and 10 inches wide may have 3 inches of bright sap, or in lieu of sap two small sound knots, or 1½ inches of bright sap and one small sound knot. Pieces 12 inches wide may have 4 inches of bright sap, or in lieu of sap one standard knot, or two small sound knots, or 2 inches of bright sap and one small sound knot. Pieces 14 inches or wider may have more defects in proportion as the width increases.

58. *"B" Finish.*—Pieces 4 inches, 5 inches and 6 inches wide may have 2 inches of bright sap and one or two small sound knots, or in lieu of knots may have all bright sap. Pieces 7 inches and 8 inches wide may have 3 inches of bright sap and two small sound knots, or in lieu of knots may have all bright sap. Pieces 9 inches and 10 inches wide may have 4 inches of bright sap and one standard knot or three small sound knots, or in lieu of knots may have all bright sap. Pieces 12 inches wide may have 6 inches of bright sap and one standard or four small sound knots, or in lieu of knots may have all bright sap. This grade will not be furnished wider than 12 inches.

59. *"C" Finish.*—All widths in this grade shall admit small sound knots, stained sap, pin worms and other defects except shake; but none that will prevent the use of same in its full width and length as a paint grade, and will admit pieces containing one coarse defect which can be removed by making two cuts with a waste of not to exceed 5 per cent. in the one piece removed, but which pieces are otherwise "B" grade or better. This grade will not be furnished wider than 12 inches.

60. *"D" Finish.*—All widths will admit sound knots, stained sap, pin worms, slight shakes, and other defects; but none that will prevent the use of same in its full width and length as a common paint grade. This grade will not be furnished wider than 12 inches.

Siding.

61. Siding shall be 4 inches and 6 inches in width, 10 feet to 20 feet in length, and graded from the finished side, A, B, C and D.

62. *"A" Siding.*—May have 1 inch of bright sap on thin edge, and may contain one small sound knot.

63. *"B" Siding.*—May have any amount of bright sap, or if not all bright sap, may have three small sound knots, shake, split or pin worm holes not exceeding in damage the three small knots as above, and may have slight wane on the thin edge. In the absence of other defects a small amount of stained sap will be permitted.

64. *"C" Siding.*—May have one to five knots, the whole not aggregating over 3 inches in diameter, or knots, splits or other defects that can be removed in two cuts with waste not exceeding 10 per cent. of the length, or may have small amount of stained sap and pin worm holes not exceeding in damage the five small knots above described.

65. *"D" Siding.*—May have stained sap and pin wormholes, or may have other defects that will not cause a waste to exceed one-third the piece.

Flooring and Ceiling.

66. Shall be specified widths, 10 feet to 20 feet in length and graded from the finished side, or if both sides are finished, it shall be graded from the better side, A, B, C and D.

67. *"A"*—May have bright sap on one edge one-fourth its width, otherwise must be clear.

68. *"B"*—May have one-half of its face bright sap if otherwise clear, or in lieu of sap, may contain two small sound knots, or may have a split not to exceed 9 inches at one end.

69. *"C"* (10 to 20 feet)—May have all bright sap, or may have one to five knots, the whole not aggregating over 3 inches, or knots or other defects that can be removed in two cuts with waste not exceeding 10 per cent. of the length, or may have three pin wormholes, or may have check or split at one end, not to exceed 10 per cent. of the length.

70. *"C"* (4 to 9 feet)—May have all bright sap, small sound knots, stained sap, pin wormholes and other defects except shake, but none that will prevent the use of each piece the full length.

71. *"D"*—May have stained sap and pin wormholes, or may have unsound knots or other defects that will not cause a waste to exceed one-third the piece.

Partition.

72. Shall be same widths and lengths as flooring and ceiling, but shall be graded from the poorer side, A, B, C and D, same grading to apply as in flooring and ceiling.

Pickets.

73. Shall be graded No. 1 and No. 2.

74. 1 inch by 1 inch shall be Headed and S4S to $\frac{13}{16}$-inch by $\frac{13}{16}$-inch.

75. 1¼ inches by 1¼ inches shall be Headed and S4S to $1\frac{1}{16}$ inches by $1\frac{1}{16}$ inches.

76. 1½ inches by 1½ inches shall be Headed and S4S to $1\frac{5}{16}$ inches by $1\frac{5}{16}$ inches.

77. 1 inch by 3 inches shall be Headed and S4S to ¾-inch by 2½ inches.

78. No. 1.—Shall be well manufactured, bright sap, no defect and may contain one small sound knot.

79. No. 2.—Shall admit stained sap, sound knots, pin wormholes, slight shake, and pickets thrown out of the No. 1 grade because of poor manufacture.

Battens.

80. Battens, both flat and OG, are not moldings. Same are invariably used with "common" lumber and shall, therefore, be graded No. 1 barn and better, admitting all defects allowed in No. 1 barn, but none that will prevent the use of each piece in full length for batten purposes. ⅜-inch Battens shall be 1-inch strips S2S to 13/16-inch by 2½ inches and resawed, or 1 inch by 2¾ inches to 3 inches S2S and resawed. Unless otherwise specified, ⅜-inch or flat Battens shall be S2S only and resawed.

81. OG Battens shall be manufactured in the sizes and pattern shown in the Universal Molding Book.

Shingles.

82. *Bests.*—A dimension shingle, 4, 5 and 6 inches in width, 16 inches long, each width packed separately, 5 butts to measure 2 inches, to be all heart and free of shake, knots and other defects.

83. *Primes.*—A dimension shingle, 4, 5 and 6 inches in width, 16 inches long, each width packed separately, 5 butts to measure 2 inches, admitting tight knots and sap, but free of shake and other defects, but with no knots within 8 inches of the butts.

84. This grade may contain shingles clipped two-thirds of the width and one-eighth of the length on the point.

85. *Star a Star.*—A random width shingle 3 inches and wider, 14 inches to 16 inches long, otherwise the same as primes.

86. *Economy.*—Dimensions 4, 5 and 6 inches, each width separately bunched, admitting sap and sound knots, may have slight peck 5 inches from butts, imperfections on points no objection and admitting 14-inch shingles.

87. *Clippers.*—All shingles below the above grades which are sound for 5 inches from the butts, wormholes and slight peck excepted, random widths 2½ inches and wider.

88. The count of our manufacture of shingles, of all grades, is based on 4,000 linear inches in width, making 1000 standard shingles, consequently there would be only 667 6-inch shingles packed and counted as 1000 standard shingles; 5 inches dimension being counted in like proportion.

89. In making re-inspections of shingles, one bundle out of 20 bundles taken at random, shall be cut open, the results of this investigation to form the basis of arriving at the grade of the entire shipment.

SPECIAL COMMITTEE.

UNIFORM GENERAL CONTRACT FORMS.

[1] CONSTRUCTION CONTRACT FORM.

A—AGREEMENT.

THIS AGREEMENT, made this .... day of .... in the year .... by and between ....

....

party of the first part, hereinafter called the Contractor, and ....

.... party of the second part, hereinafter called the Company.

WITNESSETH, That, in consideration of the covenants and agreements hereinafter mentioned, to be performed by the parties hereto and of the payments hereinafter agreed to be made, it is mutually agreed as follows:

The Contractor shall furnish all the materials, superintendence, labor, equipment and transportation, except as hereinafter specified, and shall execute, construct and finish, in an expeditious, substantial and workmanlike manner, to the satisfaction and acceptance of the Chief Engineer of the Company...

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in accordance with the plans hereto attached, identified by the signatures of the parties hereto, or as herein described, and the following general conditions, requirements and specifications, forming part of this contract.

The work covered by this contract shall be commenced ....

.... and be completed on or before the .... day of .... 19..........................

....

time being of the essence of this contract ....

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[1] Adopted, Vol. 14, 1913, pp. 699-709, 1144-1164; Vol. 15, 1914, pp. 921, 1155; Vol. 16, 1915, pp. 92, 1037.

And in consideration of the completion of the work described herein, and the fulfillment of all stipulations of this agreement to the satisfaction and acceptance of the Chief Engineer of the Company, the said Company shall pay, or cause to be paid, to said Contractor, the amount due to the Contractor, based on the following prices:

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This agreement shall inure to the benefit of and be binding upon the legal representatives and successors of the parties respectively.

IN WITNESS WHEREOF, The parties hereto have executed this agreement in .... the day and year first above written.

WITNESS:

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....

[2]FORM OF PROPOSAL.

.... 19....

....the undersigned propose to furnish all the materials, superintendence, labor, equipment and transportation, except as otherwise specified, and to execute, construct, and finish in an expeditious, substantial and workmanlike manner, to the satisfaction and acceptance of the Chief Engineer........

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and agree to commence the work within .... days after receipt of the notice of award of the contract, and to complete the work within .... days thereafter, in accordance with the terms, conditions, requirements and specifications covered by the request for proposals made by .... dated .... for the following prices:

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(Signed) ....

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[2] Adopted, Vol. 15, 1914, pp. 921, 1155.

CONSTRUCTION CONTRACT.

B—GENERAL CONDITIONS.

Bond.

1. The Contractor agrees, at the time of the execution and delivery of this contract and before the taking effect of the same, to furnish and deliver to the Company a good and sufficient bond of indemnity to the amount of .... dollars, as security for the faithful performance, by the Contractor, of all the covenants and agreements on the part of the Contractor contained in this contract. The security in such bond of indemnity must be satisfactory and acceptable to the Company.

This bond shall remain in force and effect in such amount, not greater than that specified, as shall be determined by the Chief Engineer.

Contractor's Understanding.

2. It is understood and agreed that the Contractor has, by careful examination, satisfied himself as to the nature and location of the work, the conformation of the ground, the character, quality and quantity of the materials to be encountered, the character of equipment and facilities needed preliminary to and during the prosecution of the work, the general and local conditions, and all other matters which can in any way affect the work under this contract. No verbal agreement or conversation with any officer, agent or employé of the Company, either before or after the execution of this contract, shall affect or modify any of the terms or obligations herein contained.

Intent of Plans and Specifications.

3. All work that may be called for in the specifications and not shown on the plans, or shown on the plans and not called for in the specifications, shall be executed and furnished by the Contractor as if described in both these ways; and should any work or material be required which is not denoted in the specifications or plans, either directly or indirectly, but which is nevertheless necessary for the proper carrying out of the intent thereof, the Contractor is to understand the same to be implied and required, and shall perform all such work and furnish any such material as fully as if they were particularly delineated or described.

Permits.

4. Permits of a temporary nature necessary for the prosecution of the work shall be secured by the Contractor. Permits for permanent

structures or permanent changes in existing facilities shall be secured by the Company.

Protection.

5. Whenever the local conditions, laws or ordinances require, the Contractor shall furnish and mantain, at his own cost and expense, necessary passageways, guard fences and lights and such other facilities and means of protection as may be required.

Rights of Various Interests.

6. Wherever work being done by Company forces or by other contractors is contiguous to work covered by this contract, the respective rights of the various interests involved shall be established by the Engineer, to secure the completion of the various portions of the work in general harmony.

Consent to Transfer.

7. The Contractor shall not let or transfer this contract or any part thereof (except for the delivery of material) without consent of the Chief Engineer, given in writing. Such consent does not release or relieve the Contractor from any of his obligations and liabilities under the contract.

Superintendence.

8. The Contractor shall constantly superintend all of the work embraced in this contract, in person or by a duly authorized manager acceptable to the Company.

Timely Demand for Points and Instructions.

9. The Contractor shall not proceed until he has made timely demand upon the Engineer for, and has received from him, such points and instructions as may be necessary as the work progresses. The work shall be done in strict conformity with such points and instructions.

Report Errors and Discrepancies.

10. If the Contractor, in the course of the work, finds any discrepancy between the plans and the physical conditions of the locality, or any errors or omissions in plans or in the layout as given by said points and instructions, it shall be his duty to immediately inform the Engineer, in writing, and the Engineer shall promptly verify the same. Any work done after such discovery, until authorized, will be done at the Contractor's risk.

Preservation of Stakes.

11. The Contractor must carefully preserve bench marks, reference points and stakes, and in case of wilful or careless destruction, he will

be charged with the resulting expense and shall be responsible for any mistakes that may be caused by their unnecessary loss or disturbance.

Inspection.

12. All work and material shall be at all times open to the inspection, acceptance or rejection of the Engineer or his duly authorized representative. The Contractor shall provide reasonable and necessary facilities for such inspection.

Defective Work or Material.

13. Any omissions or failure on the part of the Engineer to disapprove or reject any work or material shall not be construed to be an acceptance of any defective work or material. The Contractor shall remove, at his own expense, any work or material condemned by the Engineer, and shall rebuild and replace the same without extra charge, and in default thereof the same may be done by the Company at the Contractor's expense, or, in case the Chief Engineer shall not consider the defect of sufficient importance to require the Contractor to rebuild or replace any imperfect work or material, he shall have power, and is hereby authorized, to make an equitable deduction from the stipulated price.

Insurance.

14. The Contractor shall secure, in the name of the Company and for its benefit, policies of fire insurance on such structures and in such amounts as shall be specified by the Chief Engineer, not exceeding

....

Indemnity.

15. The Contractor shall indemnify and save harmless the Company from and against all losses and all claims, demands, payments, suits, actions, recoveries and judgments of every nature and description brought or recovered against it, by reason of any act or omission of the said Contractor, his agents or employes, in the execution of the work or in consequence of any negligence or carelessness in guarding the same.

Settlement for Wages.

16. Whenever, in the opinion of the Chief Engineer, it may be necessary for the progress of the work to secure to any of the employés engaged on the work under this contract any wages which may then be due them, the Company is hereby authorized to pay said employés the amount due them or any lesser amount, and the amount so paid

them, as shown by their receipts, shall be deducted from any moneys that may be or become payable to said Contractor.

Liens.

17. If at any time there shall be evidence of any lien or claim for which the Company might become liable, and which is chargeable to the Contractor, the Company shall have the right to retain out of any payment then due or thereafter to become due, an amount sufficient to completely indemnify the Company against such lien or claim, and if such lien or claim be valid, the Company may pay and discharge the same, and deduct the amount so paid from any moneys which may be or become due and payable to the Contractor.

Work Adjacent to Railroad.

18. Wherever the work embraced in this contract is near the tracks, structures or buildings of this Company or of other railroads, the Contractor shall use proper care and vigilance to avoid injury to persons or property. The work must be so conducted as not to interfere with the movement of trains or other operations of the railroad; or, if in any case such interference be necessary, the Contractor shall not proceed until he has first obtained specific authority and directions therefor from the proper designated officer of the Company and has the approval of the Engineer.

Risk.

19. The work under this contract in every respect shall be at the risk of the Contractor until finished and accepted, except damage or injury caused directly by Company's agents or employés.

Order and Discipline.

20. The Contractor shall at all times enforce strict discipline and good order among his employés, and any employé of the Contractor who shall appear to be incompetent, disorderly or intemperate, or in any other way disqualified for or unfaithful to the work entrusted to him, shall be discharged immediately on the request of the Engineer, and he shall not again be employed on the work without the Engineer's written consent.

Contractor Not to Hire Company's Employés.

21. The Contractor shall not employ or hire any of the Company's employés without the permission of the Engineer.

Intoxicating Liquors Prohibited.

22. The Contractor, in so far as his authority extends, shall not permit the sale, distribution or use of any intoxicating liquors upon or

adjacent to the work, or allow any such to be brought upon, to or near the line of the railway of the Company.

Cleaning Up.

23. The Contractor shall, as directed by the Engineer, remove from the Company's property and from all public and private property, at his own expense, all temporary structures, rubbish and waste materials resulting from his operations.

Engineer and Chief Engineer.

24. Wherever in this contract the word Engineer is used, it shall be understood as referring to the Chief Engineer of the Company, acting personally or through an assistant duly authorized in writing for such act by the Chief Engineer, and wherever the words Chief Engineer are used it shall be understood as referring to the Chief Engineer in person, and not to any assistant engineer.

Power of Engineer.

25. The Engineer shall have power to reject or condemn all work or material which does not conform to this contract; to direct the application of forces to any portion of the work which, in his judgment, requires it; to order the force increased or diminished, and to decide questions which arise between the parties relative to the execution of the work.

Adjustment of Dispute.

26. All questions or controversies which may arise between the Contractor and the Company, under or in reference to this contract, shall be subject to the decision of the Chief Engineer, and his decision shall be final and conclusive upon both parties.

Order of Completion; Use of Completed Portions.

27. The Contractor shall complete any portion or portions of the work in such order of time as the Engineer may require. The Company shall have the right to take possession of and use any completed or partially completed portions of the work, notwithstanding the time for completing the entire work or such portions may not have expired; but such taking possession and use shall not be deemed an acceptance of the work so taken or used or any part thereof. If such prior use increases the cost of or delays the work, the Contractor shall be entitled to such extra compensation, or extension of time, or both, as the Chief Engineer may determine.

Changes.

28. The Company shall have the right to make any changes that may be hereafter determined upon, in the nature or dimensions of the work, either before or after its commencement, and such changes shall in no way affect or void the obligations of this contract. If such changes make any change in the cost of the work, an equitable adjustment shall be made by the Chief Engineer to cover the same.

Extra Work.

29. No bill or claim for extra work or material shall be allowed or paid unless the doing of such extra work or the furnishing of such extra material shall have been authorized in writing by the .... Engineer.

The price for such work shall be determined by the Chief Engineer, who may either fix a unit price or a lump-sum price, or may, if he so elects, provide that the price shall be determined by the actual cost, to which shall be added .... per cent. to cover general expense and superintendence, profits, contingencies, use of tools, Contractor's risk and liability. If the Contractor shall perform any work or furnish any material which is not provided for in this contract, or which was not authorized in writing by the Engineer, said Contractor shall receive no compensation for such work or material so furnished, and does hereby release and discharge the Company from any liability therefor.

If the Contractor shall proceed with such extra work or the furnishing of such extra material after receiving the written authority therefor, as hereinbefore provided, then such work or material, stated in the written authority of the Engineer, shall be covered, governed and controlled by all the terms and provisions of this contract, subject to such prices as may be agreed upon or fixed by the Chief Engineer.

If the Contractor shall decline or fail to perform such work or furnish such extra material as authorized by the Engineer in writing, as aforesaid, the Company may then arrange for the performance of the work in any manner it may see fit, the same as if this contract had not been executed, and the Contractor shall not interfere with such performance of the work.

Property and Right of Entry.

30. The Company shall provide the lands upon which the work under this contract is to be done, except that the Contractor shall provide land required for the erection of temporary construction facilities

and storage of his material, together with right of access to the same.

The Contractor shall not ship any material or equipment until he has received written notice from the Engineer that he may proceed with said work or any part thereof.

Unavoidable Delays; Extension of Time on Parts of Work.

31. If the Contractor shall be delayed in the performance of the work from any cause for which the Company is responsible, he shall, upon written application to the Chief Engineer at the time of such delay, be granted such extension of time as the Chief Engineer shall deem equitable and just.

Suspension of Work.

32. The Company may at any time stop the work, or any part thereof, by giving .... days' notice to the Contractor in writing. The work shall be resumed by the Contractor in ten (10) days after the date fixed in the written notice from the Company to the Contractor so to do. The Company shall not be held liable for any damages or anticipated profits on account of the work being stopped, or for any work done during the interval of suspension. It will, however, pay the Contractor for expense of men and teams necessarily retained during the interval of suspension, provided the Contractor can show that it was not reasonably practicable to move these men and teams to other points at which they could have been employed. The Company will further pay the Contractor for time necessarily lost during such suspension at the rate of .... per cent. per annum on the estimated value of materials, equipment and fixtures furnished by the Contractor on the work which are necessarily idle during such suspension, said rate of .... per cent. per annum being understood to include depreciation, interest and insurance. But if the work, or any part thereof, shall be stopped by the notice in writing aforesaid, and if the Company does not give notice in writing to the Contractor to resume work at a date within .... of the date fixed in the written notice to suspend, then the Contractor may abandon that portion of the work so suspended and he will be entitled to the estimates and payments for such work so abandoned, as provided in Section 38 of this contract.

Expediting Work, Correcting Imperfections.

33. (a) If the Chief Engineer of the Company shall at any time be of the opinion that the Contractor is neglecting to remedy any imperfections in the work, or is not progressing with the work as fast as necessary to insure its completion within the time and as required by

the contract, or is otherwise violating any of the provisions of this contract, said Chief Engineer, in behalf of the Company, shall have the power, and it shall be his duty to notify the Contractor to remedy such imperfections, proceed more rapidly with said work, or otherwise comply with the provisions of this contract.

Annulment.

(b) The Company, if not at fault, may give the Contractor ten (10) days' written notice, and at the end of that time, if the Contractor continues to neglect the work, the Company may provide labor and materials and deduct the cost from any money due the Contractor under this agreement; and may terminate the employment of the Contractor under this agreement and take possession of the premises and of all materials, tools and appliances thereon, and employ such forces as may be necessary to finish the work. In such case the Contractor shall receive no further payment until the work shall be finished, when, if the unpaid balance that would be due under this contract exceeds the cost to the Company of finishing the work, such excess shall be paid to the Contractor; but if such cost exceeds such unpaid balance, the Contractor shall pay the difference to the Company.

Company May Do Part of Work.

(c) Upon failure of the Contractor to comply with any notice given in accordance with the provisions hereof, the Company shall have the alternative right, instead of assuming charge of the entire work, to place additional forces, tools, equipment and materials on parts of the work for the purpose of carrying on such parts of the work, and the Contractor shall be allowed therefor the contract price. The Company may retain the amount of the cost of such work, with .... per cent. added, from any sum or sums due or to be come due the Contractor under this agreement.

Annulment Without Fault of Contractor.

34. (a) The Company shall have the right at any time, for reasons which appear good to it, to annul this contract upon giving thirty days' notice in writing to the Contractor, in which event the Contractor shall be entitled to the full amount of the estimate for the work done by him under the terms and conditions of this contract up to the time of such annulment, including the retained percentage. The Contractor shall be reimbursed by the Company for such expenditures as in the judgment of the Chief Engineer are not otherwise compensated for, and as are required in preparing for and moving to and from the work;

the intent being that an equitable settlement shall be made with the Contractor.

Notice—How Served.

(b) Any notice to be given by the Company to the Contractor under this contract shall be deemed to be served if the same be delivered to the man in charge of any office used by the Contractor, or to his foreman or agent at or near the work, or deposited in the postoffice, postpaid, addressed to the Contractor at his last known place of business.

Removal of Equipment.

(c) In case of annulment of this contract before completion from any cause whatever, the Contractor, if notified to do so by the Company, shall promptly remove any part or all of his equipment and supplies from the property of the Company, failing which the Company shall have the right to move such equipment and supplies at the expense of the Contractor.

Failure to Make Payments.

35. Failure by the Company to make payments at the times provided in this agreement shall give the Contractor the right to suspend work until payment is made, or at his option, after thirty (30) days' notice in writing, should the company continue to default, to terminate this contract and recover the price of all work done and materials provided and all damages sustained, and such failure to make payments at the times provided shall be a bar to any claim by the Company against the Contractor for delay in completion of the work, due to such suspension or failure to pay.

Monthly Estimate.

36. So long as the work herein contracted for is prosecuted in accordance with the provisions of this contract, and with such progress as may be satisfactory to the Chief Engineer, the said Chief Engineer will on or about the first day of each month make an approximate estimate of the proportionate value of the work done and of material furnished or delivered upon the Company's property at the site of the work, up to and including the last day of the previous month. The amount of said estimate, after deducting .... per cent. and all previous payments, shall be due and payable to the Contractor at the office of the Treasurer of the Company on or about the .... day of the current month.

Acceptance.

37. The work shall be inspected for acceptance by the Company promptly upon receipt of notice in writing that the work is ready for such inspection.

Final Estimates.

38. Upon the completion and acceptance of the work, the Chief Engineer shall execute a certificate over his signature that the whole work provided for in this agreement has been completed and accepted by him under the terms and conditions thereof, whereupon the entire balance found to be due to the Contractor, including said retained percentage, shall be paid to the Contractor at the office of the Treasurer of the Company within .... days after the date of said final certificate. Before the time of payment of said final estimate the Contractor shall submit evidence satisfactory to the Chief Engineer that all payrolls, material bills, and outstanding indebtedness, in connection with this work, have been paid.

[3] BOND.

KNOW ALL MEN BY THESE PRESENTS:

....

That the undersigned..

..........................are held and bound unto the...............

......................................in the sum of...............

........................dollars, lawful money of the United States of America (or Canada, as the case may be), to be paid to said........... its successors and assigns, to which payment the undersigned, jointly and severally, bind themselves, their heirs, executors, administrators, successors and assigns.

The condition of this obligation is that if........................ CONTRACTOR, shall faithfully furnish and do everything required in the contract, executed in writing, dated.............................19.... between..Contractor, and .... Company for ....

....

....

....

this obligation shall become of no effect; otherwise it shall continue in full force.

Signed, sealed and delivered this........day of..............19....

ATTEST:

....

....

---

[3] Adopted, Vol. 16, 1915, pp. 101, 1037.

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IX.	Signs, Fences and Crossings	900-999
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